UNCLASSIFIED

FILE COPY

ORNL-2132
Engineering

THE ORGANIZATION, ADMINISTRATION, AND OPERATION OF A RADIOCHEMICAL PILOT PLANT

G. S. Sadowski

OAK RIDGE NATIONAL LABORATORY · U.S. ATOMIC ENERGY COMMISSION

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
UCC
POST OFFICE BOX P · OAK RIDGE, TENNESSEE

UNCLASSIFIED

Printed in USA. Price 50 cents. Available from the

Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

UNCLASSIFIED

27

ORNL 2132

Contract No. W-7405, eng 26

CHEMICAL TECHNOLOGY DIVISION

THE ORGANIZATION, ADMINISTRATION, AND OPERATION OF A RADIOCHEMICAL PILOT PLANT

G. S. Sadowski

DATE ISSUED: SEP 14 1956

OAK RIDGE NATIONAL LABORATORY
Operated by
UNION CARBIDE NUCLEAR COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

INTERNAL DISTRIBUTION

1. C. E. Center
2. Biology Library
3. Health Physics Library
4-5. Central Research Library
6. Reactor Experimental Engineering Library
7-26. Laboratory Records Department
27. Laboratory Records, ORNL R.C.
28. A. M. Weinberg
29. L. B. Emlet (K-25)
30. J. P. Murray (Y-12)
31. J. A. Swartout
32. E. H. Taylor
33. E. D. Shipley
34-35. F. L. Culler
36. M. L. Nelson
37. W. H. Jordan
38. C. P. Keim
39. J. H. Frye, Jr.
40. S. C. Lind
41. A. H. Snell
42. A. Hollaender
43. M. T. Kelley
44. K. Z. Morgan
45. T. A. Lincoln
46. R. S. Livingston
47. A. S. Householder
48. C. S. Harrill
49. C. E. Winters
50. D. W. Cardwell
51. E. M. King
52. W. K. Eister
53. F. R. Bruce
54. D. E. Ferguson
55. R. B. Lindauer
56. H. E. Goeller
57. D. D. Cowen
58. R. A. Charpie
59. J. A. Lane
60. M. J. Skinner
61. R. E. Blanco
62. G. E. Boyd
63. W. E. Unger
64. R. R. Dickison
65. A. T. Gresky
66. E. D. Arnold
67. C. E. Guthrie
68. J. W. Ullmann
69. K. B. Brown
70. K. O. Johnsson
71. H. M. McLeod
72. W. L. Albrecht
73. T. A. Arehart
74. J. E. Bigelow
75. B. F. Bottenfield
76. R. E. Brooksbank
77. W. D. Burch
78. F. N. Browder
79. W. H. Carr
80. W. L. Carter
81. G. I. Cathers
82. J. M. Chandler
83. L. T. Corbin
84. G. D. Davis
85. O. C. Dean
86. C. V. Ellison
87. J. R. Engel
88. J. R. Flanary
89. J. L. Gory
90. H. B. Graham
91. B. H. Hamling
92. I. R. Higgins
93. C. D. Hylton
94. R. B. Keely
95. L. J. King
96. C. E. Lamb
97. J. W. Landry
98. R. E. Leuze
99. W. H. Lewis
100. J. F. Lockmiller
101. J. T. Long
102. J. P. McBride
103. W. T. McCarley
104. R. A. McNees
105. W. T. McDuffee
106. R. P. Milford

107. E. L. Nicholson
108. E. O. Nurmi
109. J. R. Parrott
110. R. H. Rainey
111. A. L. Rom
112. G. S. Sadowski
113. J. E. Savolainen
114. E. M. Shank
115. S. H. Stainker
116. C. W. Schersten
117. W. G. Stockdale
118. J. C. Suddath
119. D. H. Summers
120. W. R. Whitson
121. H. E. Williamson
122. W. R. Winsbro
123. ORNL - Y-12 Technical Library, Document Reference Section

EXTERNAL DISTRIBUTION

124. R. F. Bacher, California Institute of Technology
125. Division of Research and Development, AEC, ORO
126-800. Given distribution as shown in TID-4500 (11th ed.) under Engineering category (300 copies - OTS)

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

Foreword

This manual was prepared as a summary of administrative, organizational, and operating experiences from several pilot plant programs. It is intended as a guide for all technical personnel in the pilot plant to help them bridge the gap between the neophyte stage and the time when they become fully trained pilot plant engineers or chemists.

In order to lend cohesiveness to this manual, a typical pilot plant program, the organization and operation of the Thorex Pilot Plant, was chosen as a model. However, the writer has also borrowed heavily from other programs, principally the Purex and Test Facility programs. Most of the information summarized in this manual is based on undocumented letters, notes, and memoranda in the files of the Chief of the Pilot Plant Section. Where references have been documented, they are listed in the Bibliography.

Several persons contributed to this manual by describing their duties and responsibilities as members of pilot plant or other groups. The contributors were:

J. L. Gory - Shift Supervision
H. B. Graham - Budgeting
L. J. King - Communications
C. E. Lamb - Analytical Services
W. T. McDuffee - Data Group
J. R. Parrott - Operating Group

1.0 INTRODUCTION

A pilot plant is one step in the orderly plan of chemical process development. The usual function of the pilot plant is to bring out problems arising from the integration of all phases of the process and to obtain adequate quantitative data for the design and operation of an economical production plant.[1] In addition to being a development facility, a pilot plant is a small scale production plant and has many of the characteristics of a production plant.

1.1 Objectives of Pilot Plant Programs[1]

Development programs in an ORNL pilot plant should accomplish the following primary objectives:

1. Confirm the feasibility of the proposed process.
2. Obtain quantitative engineering data necessary for the design and operation of a production plant.
3. Provide quantities of the product for large scale evaluation at other sites.
4. Bring out chemical and engineering problems which were not recognized in smaller scale development work.

1.2 Growth of a Pilot Plant

All programs that culminate in a pilot plant go through seven steps of pilot plant growth:

1. Administrative planning
2. Assignment of an engineer to follow the design of the plant.
3. Construction of the plant.
4. Testing and shakedown.
5. Operation of the plant.
6. Shutdown and dismantling.
7. Final reporting.

The growth of the pilot plant group assigned to each program follows this same pattern, reaching its largest size during shakedown and operation.

A pilot plant usually costs from $200,000 to $1,500,00 for construction and from $500,000 to $2,000,000 per year to operate. It is usually operated for one to two years primarily as a research unit, and for a longer period if the Atomic Energy Commission requires an additional production facility.

After the administrative planning step, a Problem Leader is usually given the responsibility and authority (under the supervision of the Section Chief) for the execution of the program through the remaining six steps. The Problem Leader is assigned pilot plant technical and operating personnel as required. It is the responsibility of the Problem Leader to organize his group and to delegate responsibilities, authority, and duties to the members of his group.

1.3 Typical Organization for a Pilot Plant Program

A typical organization for a pilot plant program is made up of a Problem Leader, an operations group having four rotating shifts (a shift supervisor and two or more operators per shift), a data analysis group, and an engineering group. Depending on the size of the pilot plant, five to twenty engineers and chemists and ten to twenty operators are required to staff the group.

2.0 PLANNING AND CONSTRUCTION OF A PILOT PLANT

Exclusive of laboratory, unit operations, and design studies, which may be made for several years before a pilot plant is planned for construction, the actual planning for a pilot plant begins from one to three years before construction is begun. A great deal of administrative (money and manpower budgeting, securing approvals from Laboratory management and the Atomic Energy Commission, etc.) and technical (chemical and equipment flowsheets, equipment and piping drawings, construction schedules, etc.) planning is required before construction is begun.

At this stage of planning, a Problem Leader usually will be selected for the program. Often, the Problem Leader will be loaned to the Process Design Section or the Chemical Development Section to become well-versed in the chemical and equipment flowsheets. He will be a representative for the Pilot Plant Section on the Problem Leader's Planning Committee, which is comprised of a Problem Leader from each section and other persons who have particular knowledge useful to the committee. The Problem Leader works under the direction of the Section Chief and the Project Leader (either the Associate Division Director or one of the Section Chiefs).

2.1 Administrative Planning

2.1.1 Responsibilities of Problem Leaders[2]

The responsibilities and authority which Problem Leaders should assume for their problem are essentially those which would normally be assumed by the Section Chief if there was only one problem in the Pilot Plant Section. The Problem Leader should assume full initiative for all technical and administrative phases of his problem (i. e., he should proceed as if the Section Chief were to give him little over-all guidance or assistance). The Problem Leader should act as an Associate Section Chief; that is, the Problem Leader can plan the program of his group, can speak for the Section Chief, and can commit his section to certain courses of action with a very high probability that the Section Chief will be in complete agreement with the action taken.

The Problem Leader should have the same grasp of the over-all technical and administrative features of the problem (including chemistry, unit operations, and design) as he would be expected to have if he were director of the entire project for the Chemical Technology Division. In some cases he must assume initiative for division-wide leadership, even though he is not specifically charged with this responsibility.

The Section Chief should be kept well informed on all significant developments and decisions, especially where other sections are concerned. Any matter on which an exception to company policy appears to be desirable should be referred to the Section Chief.

2.1.2 The Committee System for Program Planning[3]

The organization for accomplishing development programs in the Division is as follows: The division director has personal responsibility for the successful progress of each of the division programs. He (assisted by a Project Leader) must frequently review in detail the status (technical objectives, progress, budget, schedules) of each project to determine if satisfactory progress is being made.

Each Section Chief is automatically delegated the responsibility for an area of development: chemical development, unit operations, pilot plant or process design. Problem Leaders are appointed by the Section Chiefs for each development program and are delegated the authority and responsibility for the prosecution of the problem in their section.

One of the most important responsibilities of a Section Chief is the coordination of his section's work with that of other sections. Most of the responsibility for this coordination is delegated to the Problem Leader, and the "Committee System" is the organizational technique used by the Problem Leader to effect the coordination. The "Committee System" in action is a meeting of Problem Leaders, acting as Associate Section Chiefs for their problem, each Problem Leader having the objective of presenting the status of work in his section, outlining the information required from other sections, soliciting and offering constructive criticism, asking for and giving schedules and deadlines for required information, and pushing for joint decisions or mutual agreements required for the intelligent conduct of the work in his own section.

2.1.3 Project Leader(4)

The Associate Division Director or one of the Section Chiefs is designated as Project Leader for each of the major programs in the Division. The Project Leader is responsible for establishing Division objectives, schedules, and budgets; he coordinates the work of the sections, and he makes decisions for efficient conduct of the over-all program.

This feature of project organization supplements the Division Director - Section Chief relationship. The section structure is unchanged; Section Chiefs have technical and administrative responsibility for their sections.

2.2 Information Required for Technical Planning(1)

The cost of building and operating a pilot plant depends largely on the adequacy of the chemical, equipment, and design information which should be available at the start of the pilot plant program. In order to reduce the pilot plant construction cost to a minimum and to shorten the time required for the pilot plant program, some fundamental information must be available. There are many occasions when it might appear necessary to proceed with pilot plant development without some of the fundamental information, but in each case the increased cost of the over-all development program should be realized, and the possible increase in time required for the over-all development program should be considered.

2.2.1 Chemical Information

2.2.11 Chemical Flowsheet

The chemical flowsheet should be complete, including feed preparation, waste treatment, recovery of recycle streams (such as solvent), and preparation of all solutions entering the process. Loss data for each waste stream and decontamination factors for each product stream should be accurately known and should be given in the chemical flowsheet. The product specifications should be established; savings in excess of one-half million dollars will be realized for each major pilot plant development program in which product specifications can be met without the need for revisions of the original chemical flowsheet.

Information is needed which gives the detailed background of the flowsheet conditions; this information should present all data required for pilot plant personnel to understand and to defend the chemical flowsheet, particularly those portions of the flowsheet which might be exceptionally difficult or costly to operate.

2.2.12 Flowsheet Specifications

Quantitative data are required on the effect of variations from flowsheet conditions. The following information is needed for each stream composition and flow ratio:

1. Limits within which no significant chemical effect could be observed.
2. Limits within which the flowsheet performance would be satisfactory.
3. Quantitative comments on the effect of permitting certain variables to be out of specification.

2.2.2 Materials Information

A knowledge of the properties and specifications of all chemicals used in the process are required. Detailed specifications for the product streams are needed.

2.2.3 Analytical Information

Analytical methods for all chemicals which affect the process are required. Simplified production control methods should be available in addition to research type methods which are required for much of the pilot plant program.

2.2.4 Equipment Information

New types of equipment and instrumentation to be used in the pilot plant should be designed on the basis of thorough unit operations development and demonstration, and satisfactory operation in the pilot plant without equipment modification should be assured. Reports are needed which cover details of the equipment development program, including information which indicates that scaleup is feasible and which lists the scaleup data required for the pilot plant. Data are needed on expected equipment performance characteristics and probable corrosion rates over a wide range of operating conditions. Operating instructions for the equipment and technical assistance during startup are required.

2.2.5 Design Information

2.2.51 Preliminary Production Plant Design

Before the pilot plant is engineered and built, the production plant should be carefully visualized and a considerable amount of tentative design work completed. Preliminary design should include a study of required plant capacity, the calculation of required nuclear data, the preparation of process and equipment flowsheets, the development of heat, activity, and material balances, an estimate of the analytical requirements, the preparation of tentative specifications for equipment and materials, the preliminary sizing and design of all major items of equipment, a shielding analysis, the drawing of preliminary plant and equipment layouts, and the preparation of cost estimates. Provisions for testing equipment, emergency shutdowns, reduced throughput, recovery of valuable materials, recycle of certain streams, and other operations out of the ordinary must all be taken into account in the preliminary design. One reason for preparing a tentative design of the large plant is to determine what information is needed from the pilot plant. A formal report covering in detail the preliminary production plant design is required by the pilot plant.

2.2.52 Pilot Plant Design

a. Plant design information to be obtained in the pilot plant. It is usually impossible to cover every phase completely at the pilot plant stage and thus remove every element of chance in the final production unit. A selection has to be made between the phases to be emphasized and those lesser phases which can be safely left to component equipment development, previous analogous experience, and intelligent estimate. A list should be prepared of those phases which will be covered in the pilot plant and for which detailed data will be required. A second list should be prepared covering items in the pilot plant from which performance data will not be required for the design of the production plant.

b. Required pilot plant design data. The design group should furnish material balance and equipment flowsheets, copies of purchase requisitions, detailed drawings of items requiring shop fabrication, manpower estimates, cost estimates, equipment lists, equipment manuals, and other drawings or job lists necessary for field fabrication. A detailed list of data to be obtained on each piece of equipment should be furnished. The assistance of at least one member of the design group will be required in the field during construction.

2.3 Construction

2.3.1 Responsibility for Construction

The responsibility for organizing and supervising a pilot plant construction program may be delegated to either the Design Section or the Pilot Plant Section depending on the availability of technical manpower and the qualifications of the engineers in the sections. The engineer who acts as liaison between the Chemical Technology Division and the Engineering and Maintenance Division during construction must not only have considerable knowledge of the process and equipment to be installed, but must also have had some previous construction experience, for in this key job thousands of dollars can be wasted though inexperience and lack of knowledge, and construction schedules can be seriously delayed through poor coordination and insufficient planning.

Usually, the liaison engineer is selected by agreement between the Design and Pilot Plant Sections. When the Design Section is responsible for construction, design people who designed and followed construction of the plant are subsequently transferred to the pilot plant on a full time, long term basis for testing, start-up, and extended initial operation of the new pilot plant.

2.3.2 Preparation of a Construction Planning Schedule(5)

When a project enters the construction phase, the Chemical Technology Division and the Engineering and Maintenance Division agree on a completion date that everyone will do their best to meet. However, the schedule must take realistic cognizance of the routine and emergency maintenance responsibilities of the Engineering and Maintenance Division, the need for economical distribution of crafts, and the availability of craft manpower.

In order for the Engineering and Maintenance Division to prepare a construction planning schedule, the Design Section must provide a complete and detailed design. Because the design of the Thorex Pilot Plant was less than 70% complete at the time a construction schedule had to be prepared, a preliminary planning schedule was prepared by the Chemical Technology Division, and after being reviewed and modified by the Engineering and Maintenance Division, the schedule was accepted as binding on both divisions. Inaccuracies in the estimates accompanying the schedule were compensated by varying the craft manpower assigned to the job so that insofar as was possible, the schedule was maintained. The Chemical Technology Division prepared the schedule in such detail that the progress and status of construction could be followed on a week-to-week basis.

In order to construct the Thorex Pilot Plant efficiently and economically, the area engineer and the area foreman (from the Engineering and Maintenance Division) had no duties other than construction of the pilot plant. Also, the area foreman was given complete field authority over all crafts assigned to the project in the field (this authority did not include craftsmen working on the project in the shops; they continued under the authority of their craft foremen).

2.3.3 The Organization of a Construction Program[(6)]

A report by J. P. Jarvis, "The Organization of a Construction Program" (ORNL CF 55-3-207), describes in detail how a construction program is planned and effected. The following is quoted verbatim from the report:

"Plant construction requires an efficient organization versed in planning, scheduling, and estimating methods to hold the construction cost to a minimum and to complete the construction project on a scheduled date. During the construction of three units at Oak Ridge National Laboratory, methods were devised for:

1. Predetermining manpower requirements;
2. Utilizing manpower efficiently by scheduling;
3. Obtaining a cost estimate of construction by a detailed breakdown of manpower and material requirements;
4. Determining the job status throughout the construction periods; and
5. Estimating a realistic completion date for the job.

"These methods were designed chiefly for jobs costing from 0.5 to 10 million dollars. The scheduling methods are put into effect after the project design is 60 per cent complete.

"The key to an organized construction project is a detailed schedule. A detailed schedule is composed of a series of breakdowns of the job as follows:

1. The job is divided into geographic areas (such as cell 1, cell 2, and control room) or functional areas (such as feed preparation, extraction, and solvent recovery).
2. The areas are broken down into phases of construction, such as structural, equipment, piping, electrical, and instrumentation.
3. The work required to complete each phase is itemized, such as excavate for a pump foundation, build forms, pour concrete, set the pump, and provide power to the pump.

"After completion of the job breakdown, the craft manpower required to complete each item is estimated and written on the schedule. The sum of these estimates plus 10 per cent for supervisors, 10 per cent for services (such as truck drivers, crane operators), and 15-25 per cent for contingencies is the estimated craft manpower required to complete the job. This manpower estimate is then broken down by crafts to determine the man-days required by each craft. With this information and a knowledge of the number of craftsmen available, or the number of craftsmen that can be worked on the job efficiently, scheduled starting and completion dates are established for each item on the schedule. A summary of the scheduled manpower is made and a scheduled completion date is established for the job.

"Determining construction progress is simplified by comparing actual progress to scheduled progress. After the craft manpower required to complete each item listed on the schedule has been estimated, these estimates are used as a basis to determine the craft manpower ahead and behind schedule. The difference between these is the status of the job in man-days. A check of the estimates can be made by a comparison of estimated manpower to actual manpower, and if estimating errors are excessive, an error factor can be determined and the job status reported accordingly.

"Since the progress of a construction job is dependent upon material and equipment deliveries, special attention should be given to estimating, ordering, procuring, storing, and issuing of materials and equipment. A purchase status report and a physical inventory report should be available to the scheduler as a means of checking the availability of materials and equipment for scheduled jobs. These reports also serve as a guide in revising the schedule when necessitated by material shortages."

2.3.4 A Program for Improving Construction Efficiency

During construction of the Thorex Pilot Plant, a meeting was held with maintenance personnel each Wednesday morning at 9 a.m. The long range objectives of these meetings were to improve maintenance service and to reduce maintenance cost. The immediate objectives of the meetings were:

1. To gain the confidence of maintenance people by telling them what was being done in the pilot plant, why it was being done, and by generally convincing them that the pilot plant approach was reasonable. It was necessary to tell how pilot plant work fits into the Chemical Technology Division and into the general Atomic Energy Commission program. It was necessary to convince maintenance personnel that the very nature of development work was change (always modifying, improving); if maintenance personnel do not understand changes due to improvements, they feel that many equipment changes are due to poor engineering, etc. and lose confidence in the pilot plant.
2. To convince maintenance personnel that the pilot plant realized the need for their help, by reviewing pilot plant plans and by giving maintenance personnel a chance to criticize these plans.
3. To pass on to maintenance personnel information which they needed for long range scheduling of work.

The meetings were conducted by the Chief of the Pilot Plant Section and the Thorex Problem Leader. The attendees from the Mechanical Department were: the lead engineer, the area engineer, the general field supervisor, and the area supervisor.

The meetings were held once each week and lasted about 90 minutes. In addition to explaining how the pilot plant fits into the work of the Chemical Technology Division and the Atomic Energy Commission, the background of various processes was presented. Chemical flowsheets were explained in language which the maintenance personnel could understand, and preliminary equipment flowsheets were reviewed and criticism and comments were received from these personnel before equipment drawings were approved.

These meetings were very profitable and the Mechanical Department requested that this type of program be conducted for other pilot plant programs.

2.4 Testing and Shakedown of Equipment

Prior to operation of a pilot plant, the pilot plant equipment is inspected, tested, and operated individually and in component groups to determine that the equipment is installed as designed and will operate as intended. This work is usually done after the construction group has completed its work except for completing finishing work such as painting, insulating, and labelling equipment.

Preoperation work is done by the pilot plant group, usually with the assistance of personnel from the other sections who have designed the equipment.

Prior to testing and shakedown of the Thorex Pilot Plant, a program for testing and shakedown was written and published(7), and after the program was completed, an evaluation report was written(8).

3.0 OPERATION OF A PILOT PLANT

After a newly constructed pilot plant has been tested and the equipment is ready to be operated, either in units or as an integrated system, the pilot plant group is organized for operating the plant. The problem leader is responsible for properly executing the demonstration and development program for which the plant was built.

In recent years the Pilot Plant Section has become engaged in several large programs at the same time without appreciably increasing its manpower, and as a result, the number of persons assigned to each program is less than would have been assigned in former years. However, the basic organization for a pilot plant program has not changed significantly---fewer people are assigned to the group.

3.1 General Organization of a Pilot Plant Group

The basic organization consists of the Problem Leader as the person responsible to the Section Chief for the conduct of the program. Under the supervision of the Problem Leader is an engineering group, a data group, a construction and maintenance engineer, and an operating group(9) Some pilot plants may also have a process chemist. In some pilot plants, the construction and maintenance engineer may be a part of the engineering group to handle both process engineering and maintenance, and the process chemist may be a part of the data group.

Also, for some problems involving newly developed equipment which has not been tested with radioactivity or on a large scale, engineering assistance may be assigned to the pilot plant for a few months from the Unit Operations or Process Design Sections.

A process chemist may be assigned by the Chemical Development Section either full time to the problem to work as a member of the group, or he may assist the group as a consultant on a part-time basis.

Although most pilot plants are organized in this manner, there are exceptions. The Homogeneous Reactor Test (HRT) Chemical Plant will be operated by Chemical Technology Division personnel, mostly from the Pilot Plant Section, on loan to the Reactor Experimental Engineering Division and under the direction of the Project Leader, who is responsible for both reactor and chemical plant. The pilot plant engineer, who normally would be the Problem Leader, in this case has the title of Chemical Plant Coordinator, although most of his duties are the same as outlined for a problem leader. The organization in this case is not as separate and clear-cut as in most pilot plants, and some of the responsibilities and duties will be assumed by the over-all HRT organization. Operation of the chemical plant will be the responsibility of the HRT shift supervisor.

3.2 The Problem Leader

The scope of a Problem Leader's responsibility has been described in Section 2.0. During the period of planning for a pilot plant, the Problem Leader is concerned with the technical aspects of the problem. When the plant is operating, the Problem Leader takes on many additional duties, such as supervision of several technical personnel and operators, establishing a radiation control program, and obtaining analytical and maintenance services. Safety, budgeting, obtaining supplies, reporting data, and conducting meetings are important in his daily work.

3.2.1 Organization During Startup

During startup of a pilot plant, particularly when there are several unknowns in the chemical or equipment flowsheet, a daily meeting of all the Problem Leaders (also some Section Chiefs or other technical personnel who have specialized knowledge of the process) can be helpful in getting the plant running as quickly as possible.

During startup of the Test Facility, a meeting was held at 9 a.m. each day in the Test Facility Problem Leader's office. The purpose of the meeting was to expedite the startup by making everyone concerned aware of the daily progress and the problems being encountered.

The meetings were highly successful. Many good recommendations were received during the meetings, and many profitable supporting investigations were initiated in the other sections as a result of the meetings.

3.2.2 Formulation of a Program

Though the over-all program objectives of any pilot plant are those enumerated in the Introduction, the immediate and future program for a pilot plant must be given careful and detailed thought by the Problem Leader. The Problem Leader often has to adapt his immediate program to the availability of feed materials, to unexpected process data, to equipment failures, to equipment additions or alterations, to manpower changes, and to many other factors that can either delay or accelerate the program. Many times, these factors serve to confuse the direction of the problem, making it imperative for the Problem Leader to recall clearly the over-all program plan and to make decisions which are consistent with the long-range objectives.

For budgeting purposes, programs are planned for three fiscal years; for the current year and the next year the manpower and money requirements are planned on a month-by-month basis. For the third year, the manpower and money requirements are shown as annual totals.

Pilot plants are rarely constructed without planning for continued growth or expansion in a three-year period. Additional process cycles may be added, more highly irradiated and shorter decayed feed may be processed, the capacity of the plant may be increased, or the plant may gradually shift from all development work to straight production work. If a problem leader is to plan a long-range program intelligently, he must know the long-range plan of the Pilot Plant Section and other sections in the division, because his plans will affect and will be affected by the plans of these other groups.

3.2.3 Technical Coordination with Other Sections

Just as in the planning stage for a pilot plant when the program is a joint effort of all sections in the division, the operation of the pilot plant requires joint effort of all sections, although the primary responsibility for operating the plant lies with the Pilot Plant Section. Aside from program planning, the Problem Leader should communicate frequently with problem leaders in other sections to make sure that the supporting work for the pilot plant (laboratory studies, design work, unit equipment testing, etc.) is being carried out in the best interests of the program and the division. Often, the Problem Leader will have to make technical decisions when he does not have sufficient technical information, or will be faced with a problem which he does not fully understand because of insufficient information, making it necessary to call on expert assistance from other sections. The Problem Leader should remain in close touch with other problem leaders so that the technical effort of the whole division is coordinated and directed for the best interests of the Laboratory.

3.2.4 Supervision of Technical Personnel and Operators

One of the most difficult tasks for a new problem leader is to organize his assigned manpower effectively and to delegate responsibilities and authority to the technical supervisors. The Problem Leader is responsible for the administration and leadership of all operators assigned to his problem. He is responsible for their assignments, training, personal development, safety and general well-being. It should be made obvious to the operators that the Problem Leader is personally concerned with their progress and will see that they get a square deal.

The relation of the Problem Leader to the technical personnel assigned to his problem is similar to the relation to operators, but is somewhat more technical and less administrative, depending on the technical person concerned. Matters such as salary, housing, and future assignments to other processes or problems must be handled by the Section Chief.

The Problem Leader should take advantage of all the experience and ability of the personnel assigned to his problem, and should delegate as much authority and responsibility as possible. He should let as many of his people as is feasible participate in the formulation of the required policies and decisions, and should advise all others of the background for the decisions.

3.2.5 Safety

Each Problem Leader is responsible for the safety of all persons assigned to him and is responsible for carrying out a well-organized, effective safety program. Although this responsibility may not be delegated by the Problem Leader, he may make assignments for specific jobs concerning safety as he wishes. Each member of the group should attend at least 30 minutes of safety meetings each month, and the Problem Leader should send the Section Chief a report of each meeting and the progress of his program.

The enforcement of safety rules where maintenance personnel are concerned is the responsibility of Mechanical Department supervision. The pilot plant should inform maintenance personnel of regulations established for pilot plant buildings, and the pilot plant should not permit maintenance work which is done in flagrant violation of established safety rules. However, normal safety practices, such as the wearing of safety glasses, should be routinely enforced by Mechanical Department supervision.

3.3 Engineering Group

The engineering group consists of a chief engineer and one or more assistant engineers. In the larger pilot plants, two or three engineers are usually assigned to the plant until smooth operation is assured, after which only one engineer may be retained. The remaining engineer may also be in charge of small construction jobs and routine maintenance.

During the design phase for a pilot plant, an instrument engineer is usually assigned to work with the design engineers. His job is to specify the types of instruments required, their construction and specifications, and to follow through the purchase of the instruments. In the pilot plant, the instrument engineer works closely with the engineering and operating groups, being concerned solely with instrumentation, and his responsibilities parallel closely those of the engineering group.

Prior to plant startup, the engineering group is responsible for putting the plant into operation. It approves all process and engineering flowsheets. It specifies procedures for cleanout and testing of the equipment, assists in the preparation of plant startup procedures, and assists the data group in organizing data sheets to insure the inclusion of all essential data. The group should also instruct and train the operating group in the proper operation of the equipment. It should assist the operating group with around-the-clock supervision of critical pieces of equipment if this is felt to be necessary. In addition to the direct assistance given to plant startup, the engineering group should make a limited (but intellectual and critical) re-evaluation (over and above the work done by the Process Design Section) of the pilot plant for operability and applicability to the over-all long-range pilot plant objectives.

If it is found that equipment or piping changes are necessary, the engineering group should specify the changes, make or approve all drawings or sketches of the changes, and should notify the construction and maintenance engineer of the required modifications. They should also specify changes in operating conditions to improve efficiency, reduce losses, and increase production. The engineering group should revise the operating or equipment manual as required by the changes.

After the plant is running smoothly, the engineering group has two functions: service to operations and equipment development.

3.3.1 Service to Operations

The engineering group is always on call to the operating group to troubleshoot process difficulties, either by advising the shift supervisor of the corrective action to be taken or by personal attention (see Section 3.5.4). Other responsibilities are to:

1. Specify the equipment conditions for each run and the process and engineering data to be taken during the run for equipment evaluation, and to approve the sampling schedule for the run.
2. Evaluate equipment performance during each run and write an equipment evaluation report, and assist the data group in interpreting data when requested.
3. Provide additional technical coverage on shifts when required, acting as an assistant to the shift supervisor.
4. Make special tests of equipment independently of the operating group but only under special well-coordinated conditions.

3.3.2 Equipment Development

The development of all techniques and equipment which show promise should be followed, and consideration should be given to their utilization in the pilot plant when it appears that operations could be simplified or that a contribution to the field of radiochemical processing could be made. Some of the more important functions of process engineering are to:

1. Design the required new equipment, and specify modifications necessary on the existing plant.
2. Make detailed analysis of all critical items of equipment; for instance, analyze each column and its accessories to ensure that pressure pot heights, jackleg seals, etc. are adequate for startup, equilibrium, and shutdown; and re-investigate as necessary with flowsheet changes.
3. Analyze all engineering data, such as column HETS data and acid recovery unit performance.
4. Prepare a list of operating data required for complete engineering analysis of equipment performance.
5. Trouble-shoot all major failures of equipment.
6. Prepare general operating instructions for all new types of equipment.
7. Prepare a simplified and schematic equipment flowsheet for the entire process.
8. Follow development of equipment related to (but not necessarily critical to) the pilot plant operations, and investigate the feasibility of installing in noncritical process streams or pilot plant equipment testing rooms certain types of promising but unproven equipment or certain types of proven equipment on which local experience is lacking.
9. Follow pertinent activities of the Unit Operations Section.

3.4 Process Chemist and Data Group

3.4.1 Process Chemist

The process chemist for a pilot plant program is usually a person who has had considerable experience in the chemical development section developing the chemical flowsheet through laboratory studies. When assigned to the pilot plant, the process chemist is responsible for all pilot plant matters pertaining to the chemistry of the process, and his long-range goal should be to make a vigorous effort to improve all features, including basic features, of the chemical flowsheet. Working closely with the problem leader, he should coordinate pilot plant activities with the Chemical Development Section, informing the problem leader in the Chemical Development Section of any difficulties with process chemistry. He should keep informed of the progress of long-range laboratory investigations.

All pilot plant reports pertaining to process chemistry are either written by the chemist or approved by him if written by other pilot plant personnel.

More specifically, the duties and responsibilities of a process chemist are to:

1. Prescribe the chemical conditions for each run.
2. Assist the Problem Leader in formulating a long-range program of runs that is consistent with the over-all objectives of the program.

3. Prepare and distribute the necessary chemical flowsheets.
4. Prepare a sampling schedule for each run, including a listing of samples to be taken, sample volumes, and analyses required.
5. Ensure that the analytical methods are adequate and that the precision of the methods as run in the analytical laboratory are satisfactory, and make the final decision as to when samples may be discarded.
6. Ensure that the chemical data are being recorded and calculated in a satisfactory manner.

For some pilot plant programs, the process chemist was a member of the data group, calculating and analyzing data, and for other programs the process chemist had supervisory status by himself. Each system has its advantages, depending on the total manpower available, the chemist, and the work load. If the process chemist is made a part of the data group, he may become engrossed in details and is apt to lose perspective and spend insufficient time for planning. In another case, the chemist may not desire to be responsible for making routine calculations or tabulations of data, preferring to serve as a technical consultant to the entire group; this type of person would not be suited to a data group. Thirdly, the pilot plant group may not have sufficient manpower to enjoy a process chemist as such, and it may be necessary for the chemist to assist the data group. Each of these situations must be weighed by the Problem Leader before he places the process chemist in his organization.

3.4.2 <u>Data Group</u>

A data group usually consists of a chief, one or more data tabulators, and one or more data analysts. The data tabulators are usually nontechnical personnel having one or two years of college training, while the data analysts are technical personnel.

The data group is primarily responsible for analyzing the chemical results from process operations, correlating the results with prior knowledge, and making recommendations for process improvements.

The specific responsibilities and duties of a pilot plant data group are to:

1. Formulate objectives and outline means of achieving them.
2. Assemble all the data incidental to a particular run or phase of of the program under consideration; these data remain in the custody of the data group, and they should provide a systematic method of storing and cataloging the data.
3. Evaluate all the data that have been assembled and distribute any information that is of interest as soon as it is assembled and evaluated.
4. Issue run summaries at the conclusion of each run, contribute to all other periodic pilot plant reports pertaining to process evaluation, and issue reports at the conclusion of each phase of the program or when some special problem study has been completed; the data group should study reporting techniques to improve the quality of the reports.
5. Maintain up-to-date records for S. S. Accountability and inventory purposes; these records should show such data as cumulative and daily losses of valuable materials, a complete description, location, and inventory data of all feed and product materials as well as process materials such as solvent, diluent, reducing reagent, eluting reagents, etc.

6. Establish specifications for finished products and process reagents; it is necessary to determine whether or not the products from a given run, conducted under a particular set of conditions, meet some predetermined specifications; the required purity of the process reagents is governed largely by the specifications that have to be met.
7. Establish and distribute sampling schedules (samples to be taken, sample volumes, and analyses required) prior to the beginning of every run to ensure that sufficient samples are obtained to furnish the necessary information for evaluation of the run.
8. Keep the analytical group fully advised of run conditions, run schedules, and the sampling and analytical requirements.

3.4.3 Data Analyst

The data analyst has a very important job in a pilot plant group, because the results of his personal work and thoughts are reported to persons outside the pilot plant group, and these reports establish the reputation of the pilot plant to remotely located persons who have little or no personal contact with the group. The data analyst should be an experienced engineer or chemist; he should have a personal incentive to do thoroughly professional work and have integrity and imagination.

A data analyst should be thoroughly familiar with the process chemistry involved in the program, having had some previous experience either in operating similar processes or in the development of radiochemical processes. He should have some knowledge of the design criteria for construction of the pilot plant, and some feeling for the philosophy that is followed by the operational groups. This will help him to understand pilot plant goals better and to suggest means of attaining them. It will also help him to plan for obtaining process data required to evaluate the process. Of considerable importance is the feeling for design and behavior of equipment, or the engineering viewpoint; he should realize that all equipment has limitations as well as definite capacities built into it.

The desire and ability to determine the causes of events is one of the most important qualifications of a data analyst. It is not sufficient to report just what is seen; it is equally important to ascertain that the reported data and conclusions are based on a complete study of the problem. The data analyst should take considerable professional pride in his work. This will stimulate him to seek ways and means to improve himself as well as his work. He should also have an objective viewpoint toward all the work assigned to him. This tends to eliminate bias and snap judgments based on elementary or incomplete data.

The integrity of a data analyst is probably one of the most important qualifications. He will show a willingness to come to a decision once all the facts are at hand and will defend a position which is supported by facts. The competent data analyst will be quick to accept responsibility for all his work.

Imagination is also an important qualification for a data analyst. Masses of data tend to become just so many figures unless the analyst is able to recognize the full scope and importance of the program in which he is engaged. A lively imagination will give an analyst a positive attitude toward all possibilities. He will think situations through to a definite conclusion. He will quickly weed out unproductive ideas, and as a natural result of thorough thinking, he will enhance the reputation of the pilot plant group.

3.4.4 Data Tabulators

Nontechnical personnel can handle as much as 75 per cent of the routine duties of a data group. They can easily handle the following:

1. Assembling and tabulating data.
2. Making routine calculations.
3. Posting current records.
4. Maintaining close liaison with the operating group and recording the details of operation.

The ability of nontechnical personnel to do the following depends wholly on the individual and the amount of training that can be given to the individual by the technical personnel:

1. Evaluating data.
2. Determining product specifications.
3. Making calculations involving decay chains.
4. Recognizing chemical trends at other sites or keeping up with literature.
5. Making engineering evaluations and calculations.

Nontechnical personnel require more training and supervision, initially, than technical personnel. A data group having a sufficient number of trained tabulators to handle the routine data is more stable than a group composed wholly of technical personnel, because there usually is a greater turnover of technical persons.

3.5 The Operating Group

The operating group of the Thorex Pilot Plant consists of a chief and assistant chief of operations, four technical shift supervisors, eight rotating-shift operators, and two day-shift operators.

The primary functions of the operating group are to operate the plant according to preset conditions and to record operational data and information required by the data and engineering groups to evaluate each run. In order to carry out these functions, the operating group has many duties, most of which are routine. Many of these duties are co-shared by the chief and assistant chief of operations, and many are delegated to the shift personnel and day-shift operators.

3.5.1 Duties of the Operating Group

The duties of the operating group are to:

1. Maintain an up-to-date manual of all equipment in the plant.
2. Prepare and maintain an up-to-date operating manual.
3. Organize and carry out a training program for all operating personnel prior to plant startup, during operations, and during shutdown. Also train new personnel received into the group.
4. Follow through the preparation of run sheets from the rough draft stage through reproduction and final issuing; obtain all approvals necessary before the start of a run.
5. Check daily all process data being recorded on run sheets; the data should be recorded accurately and completely.
6. Check daily (inspect equipment, recorded data on instrument charts and analyses reported) to see that all process operations are being conducted according to the preset conditions.

7. Coordinate the pilot plant operations with the special desires of other groups, such as special data or samples for chemists, operating test equipment for engineers, or making allowances for maintenance repair or modifications.
8. Devise special operating procedures or techniques, and instruct operators in their use, as required to keep the plant operating or to fulfill special requests, e. g., to obtain a large sample of process solution, to minimize overexposures when the radiation level of some piece of equipment increases unexpectedly, or to redissolve a precipitate in a product solution.
9. Prepare and maintain a complete set of operations log books to record losses, waste volumes, maintenance, program, solution make-up, etc.
10. Test and calibrate all new equipment before it is put into operation.
11. Handle all service samples; obtain shipping or storage containers and follow through their shipment or storage, obtain analyses, and prepare documents for the S. S. office.
12. Store all equipment methodically, and keep a list of the equipment and its location.
13. Maintain an up-to-date spare parts list, keep informed of the spare parts usage, and periodically take a physical inventory.
14. Order all supplies necessary for operation, keep informed of stores stocks, and prepare requests for new store stock items.
15. Inspect all equipment for wear and lubrication; take proper care of the equipment to prevent corrosion or failures.
16. Plan and execute a strong safety program. Arrange meetings, demonstrations, and talks on safety; maintain a low accident rate.
17. Maintain a stock of decontamination chemicals and materials. Devise procedures and techniques as necessary to decontaminate the plant or small areas depending on the situation.
18. When operator patrol (small jobs for other Laboratory groups) is requested, coordinate the requests with shift personnel and make certain that the patrol jobs are done correctly.
19. Keep the pilot plant facility neat and clean.
20. Prepare and maintain records of shift schedules, vacation schedules, overtime, personnel radiation exposure, and plant radiation levels. Fill out time cards, and issue clothing request forms.
21. Maintain the pilot plant vehicles in proper condition.

The chief and assistant chief of operations are directly responsible for training all operator personnel. They keep an accurate account of all maintenance requirements and inform the pilot plant maintenance engineer of the requirements. They follow maintenance work to prevent injury or exposure to crafts people and also check the work when it is complete to make sure it is in operable condition. They maintain proper cooperation between shifts on such matters as housekeeping, relieving previous shifts on time, and transferring of necessary information between shifts. The chief and assistant chief of operations must carefully read the operations log as kept by the shift supervisors and advise the Problem Leader of any unusual incidents. They keep a file of all completed log books. They maintain adequate supplies of all kinds, including chemicals, clothing, gloves, rubbers, etc., and keep a daily inventory and usage record of these materials. They are responsible for the safety of all the operators, shift supervisor, maintenance personnel, and visitors in the operating area. They must post and enforce the regulations regarding smoking, eating, washing, and clothing changes. They issue shift schedules, vacation schedules, and overtime lists. They prepare operator time cards and maintain pilot plant vehicles.

The three shift supervisors in the Thorex Pilot Plant have dual responsibilities. Since the pilot plant makes about two runs per month, or one run every other week, the shift supervisors work a five-day rotating shift every other week while the plant is in operation. On the off-week, they have other duties, such as preparing or revising run sheets, maintaining spare parts lists and inventories and ordering all necessary spare parts, and writing or revising the operating manual and the safety manual. They also assist in training new shift supervisors. In some cases, the new person works on the day shift for six weeks with the chief of operations, or if possible, the new supervisor is put on shift immediately with an older supervisor.

The eight shift operators are on a seven-day, three-shift basis, two operators being on each shift. During the week the plant is not operating, these operators do dissolving and feed preparation for the next run. It is also their duty to keep the plant contamination to a minimum, and this is done mostly during off-week operation.

Besides the shift operators, two operators work on the day shift. One of these operators tabulates all radiation exposure data received from members of the operating group, the analytical group, and the maintenance group and tabulates radiation levels in various sections of the plant. From these data, the operator determines the percentages of radiation received at various places, correlates the plant radiation levels with process operations, and issues a weekly radiation exposure report. He also keeps a complete record of all maintenance performed in the pilot plant in such form that a minimum of effort is required in writing a weekly report which is prepared by the chief or the assistant chief of operations. For each maintenance item, the operator records plant downtime caused by the failure, man-hours required to correct the failure, the over-all effect of the failure on the operation of the plant, decontamination required, and radiation exposure received while the failure is repaired. He also takes a daily plant inventory of chemicals, determines the usage rate, and keeps the inventory at a minimum.

The other day operator is used to fill in for a shift operator who is scheduled to be off on the day shift, eliminating the need for overtime while one shift is on days. This day operator also works part-time, eluting Thorex product and preparing materials for another process. Both day operators call to the attention of the chief or assistant chief of operations any malfunction of equipment which is reported by the shifts, and maintain a complete record of all complaints or suggestions made by shift personnel.

3.5.2 The Shift Supervisor

The shift supervisor is responsible for the proper operation of all pilot plant equipment which has been accepted by the pilot plant operations group, and is responsible for obtaining all data prescribed in run sheets and other instructions for operation. In addition, the shift supervisor is responsible for many other functions, such as the training and administration of all personnel assigned to his shift. The scope of the shift supervisor's responsibilities is very large; the list of specific items of responsibility listed below is not complete, but rather is intended to indicate items which are typical of those responsibilities and which may be classified as follows: organization, process operations, calculations, training, instrumentation, leadership, safety, housekeeping, administration, and maintenance.

3.5.21 Organization

The shift supervisor must maintain control over all operations assigned to the pilot plant. He should demand that all technical personnel in the pilot plant make requests for assistance directly to the shift supervisor rather than to individual operators, and the shift supervisor should assume responsibility for the completion of such requests as he approves. The shift supervisor should not permit any adjustment or operation of pilot plant equipment without his knowledge and consent. This practice is absolutely necessary to eliminate confusion, especially on the day shift. The following is an exception to the above procedure: technical personnel may request from the supervisor the temporary detail of operators for special work on equipment for which the shift supervisor is not responsible. If such requests are granted, the operator will remain under the technical supervision of the person making the request until the work is completed or until the operator is recalled by the shift supervisor, whichever is first. Whenever additional technical personnel are assigned to the shift supervisor during runs, regardless of the experience or position of this additional personnel, they report to the shift supervisor and the shift supervisor is responsible for assigning them duties which best ensure the success of the run.

3.5.22 Process Operations

The shift supervisor is responsible for seeing that all operations conducted on his shift are done in a manner which is safe, intelligent, thorough, and expeditious. Some of the typical responsibilities of the shift supervisor in connection with process operations are:

a. Run sheets and other written instructions. Shift supervisors are responsible for studying thoroughly all run sheets and other written instructions to ensure that all necessary data are obtained. Most operational mistakes and failures to collect data are caused by failure to read carefully and appreciate the intent of run sheets. The shift supervisor should request additional information on any item which is not fully understood or which appears to be in error.

b. Supervision of critical operations. The shift supervisor must personally supervise such critical operations as slug loading, coating removal, dissolving, feed preparation, column operations, and product removal; he should continually check data on buildup and depletion rates, column specific gravities, instrument controller settings, pump rates, etc. He should investigate the reasons for variations from desired performance and he should record and vigorously attempt (after intelligent reasoning and, if necessary, advice from the operations leader) to correct the cause of such variations. The shift supervisor must know the chemical flowsheet and must know the results expected from each run, and he should follow the analytical results in an effort to detect malfunctioning of equipment. In every free minute the shift supervisor should inspect the instrument panel, the gallery, penthouse, pipe tunnel, cells, and docks to detect and investigate any unusual situation.

c. Sampling. The shift supervisor is responsible for obtaining all required samples. He should frequently inspect each sample for volume, color, coding, and phase.

d. Operational reports. A significant portion of the value of a pilot plant run is lost unless a permanent record is made of the operational experience gained during the program. The prime responsibility for the recording of this experience lies with the shift supervisor. Among the more important data which should be recorded, in addition to those recorded on run sheets, are the following: unusual incidents, equipment maintenance, and radiation exposures.

e. Requests for information. When in doubt about the proper action to take on any matter, the shift supervisor is responsible for contacting immediately the proper pilot plant personnel, regardless of the time of day or night.

f. Process data. The shift supervisor is responsible for the accuracy and completion of all data obtained on his shift.

g. Operational difficulties. The specific duties of the shift supervisor in the event of operating difficulties are summarized as follows:
   1. Aggressively trouble-shoot the difficulty.
   2. Determine if the correct operating procedures are being followed.
   3. Make a detailed list of all data, including a special log of trouble-shooting activities which could be used by engineering, chemistry, and other personnel to analyze the difficulty. Make the data easily accessible to all personnel.
   4. Call on the chemistry, engineering, instrumentation, and other groups as needed to analyze the difficulty and to get advice on correcting this difficulty.
   5. Notify the chief of operations if it appears that the difficulty will delay the program more than two hours. Notify both the chief of operations and the problem leader immediately if a serious health hazard exists.

h. Calculations. The shift supervisor is responsible for all calculations made on his shift. In addition to making some calculations and checking calculations made by operators, the shift supervisor has the additional responsibility of using a great amount of caution and judgment in making use of the calculations.

3.5.23 Training

The shift supervisor is responsible for the training and orientation of all personnel assigned to his shift. Some coordination of training may at times be done by other pilot plant individuals, but this in no way relieves the shift supervisor from his responsibility. Specifically, the shift supervisor is responsible for seeing that each operator:

1. Knows how the pilot plant fits into the scheme of things at the Laboratory.
2. Knows the function of each piece of equipment and each instrument in the pilot plant.
3. Knows how to operate each piece of equipment and how to interpret each instrument reading.
4. Knows the pilot plant program and knows in general the status of the program.

5. Is protected from all health and safety hazards.
6. Knows the duties of the shift supervisor so that the operator will be better prepared as a member of the shift team.

3.5.24 Instrumentation

The responsibilities of the shift supervisor in connection with instrumentation are summarized as follows:

a. Instrument settings. The various settings for each instrument are prescribed either in run sheets or in the operating manual. The shift supervisor is responsible that no deviations are made from these settings, except in case of emergency, without prior approval of the pilot plant instrument engineer.
b. Instrument charts. The 12-8 shift supervisor should check all instruments charts to ensure that the properly numbered chart is used for each instrument, that the chart is labelled and dated correctly, and that the pen is set to proper time ± 5 minutes and is inking. All shift supervisors should make sure that the pens on all recording instruments are inking and producing a clean record.
c. Instrument operation. The shift supervisor must be continually on the alert for signs of instrument failure. He must check the various instruments against each other and against analytical data whenever possible. He should request maintenance service whenever an instrument failure is indicated, and he should record all instrument maintenance items in the operation log and in the instrument maintenance log. A note of an operational change should be made on the chart when there is any possibility that this information could be used in the analysis of operational or analytical data.

3.5.25 Leadership

The standard of leadership expected of shift supervisors is high and cannot be attained by experience alone; consequently, each shift supervisor is expected to do extensive outside reading and study to fully qualify himself for shift leadership.

3.5.26 Safety

All operations in the pilot plant should be guided by the following policy: safety comes first, followed by quality and then quantity. The shift supervisor is responsible for:

1. Reading and understanding the standard laboratory safety procedures practiced in the pilot plant.
2. Seeing that each job done, no matter how small, be accomplished without injury to personnel.
3. Seeing that each operator knows what to do if he or another operator is injured.
4. Training operators in standard safety practices and frequently informing them of any special hazards in doing their jobs.

3.5.27 Housekeeping

The shift supervisors are responsible for keeping the operating areas clean and orderly at all times.

3.5.28 Administration

The shift supervisor is responsible for a number of administrative items which concern operator overtime, vacations, time cards, and the operator evaluation system.

3.5.29 Maintenance

The shift supervisor is responsible for checking the operation of equipment and for initiating maintenance service. Every attempt should be made to repair equipment on shift with a minimum of delay to operations.

3.5.3 Organization on the Day Shift

On the day shift there is a certain amount of confusion which can be eliminated if all technical personnel would deal directly with the shift supervisor rather than with individual operators. The activities on the day shift are reasonably complex, and for this reason any long list of rules which would restrict too severely the freedom of operation probably would not be effective. However, pilot plant personnel should adhere to the following general policy:

1. All requests for work or assistance should be made directly to the shift supervisor (or in his absence, the chief operator), not to individual operators. This applies to all technical personnel.
2. Technical personnel may request from the shift supervisor the temporary detail of operators for special work. If such requests are granted, the operator will remain under the technical supervision of the person making the request until the work is completed or until the operator is recalled by the shift supervisor, whichever is first.

Violations of the above policy should be reported to the problem leader immediately and directly by the shift supervisor (or in his absence, the chief operator).

3.5.4 Designation of Responsibilities During Periods of Operational Difficulties

During periods of operational difficulties in a pilot plant, all personnel---operations, engineering, chemistry, instrument, and data personnel---have definite responsibilities. "Operational difficulty" is a very broad term, and for this reason it is difficult to define specifically the action that should be taken by various individuals during periods when things are not going smoothly. The following procedures and designation of responsibilities were developed during operation of the Purex Pilot Plant, and these, for the most part, may be applicable to any pilot plant.

It is assumed that preliminary testing, if any, on operation of the equipment under the direction of the engineering group has been completed, and that the operating group has accepted responsibility for operation of the equipment. In most cases it is necessary for the operating group to assume responsibility for operation of the equipment with little or no preliminary testing.

The first responsibility for the correction of operational difficulties lies with the operating group, and in particular with the shift supervisor. Over a period of years, however, experience has been that considerably more time was lost in the pilot plant as a result of analytical, chemistry, engineering, and instrumentation deficiencies than of improper operational techniques. For this reason it is imperative that strong assistance be rendered to the operating group by all other groups. In addition, it is also imperative that the necessary assistance be given in a systematic manner. The assistance should involve consultation, the rendering of pertinent data, and the offering of recommendations to the shift supervisor. No experimentation or corrective action to improve equipment operation should be taken by any individual without the knowledge and consent of the shift supervisor.

3.5.41 Responsibilities of the Operating Group

The operation of pilot plant equipment is the direct responsibility of the chief of operations, who also has many responsibilities other than the direct operation of equipment (such as personnel, supply, maintenance). In practice the responsibility of normal equipment operation is automatically delegated to the shift supervisor. In the event of an operational difficulty, the responsibility for equipment operation remains with the shift supervisor until such a time as he is formally relieved of this responsibility by the chief of operations or the problem leader. Specific responsibilities of the shift supervisor in the event of an equipment failure are to:

1. Aggressively trouble-shoot the difficulty.
2. Determine if run sheets are written in conformity with the standard chemical and engineering flowsheets.
3. Determine if the correct operating procedures are being followed; all necessary operating procedures should be found in the run sheets or in the operating manual.
4. Make a detailed list of all data, including a special log of trouble-shooting activities, which could be used by engineering, chemistry, and other personnel to analyze the difficulty. Make the data easily accessible to all personnel. This list of data will be the basic instrument for transmittal of information concerning the difficulty to subsequent shifts. This letter should become a part of a formal report on the operational difficulty.
5. Notify the chief of operations if it appears that the difficulty will delay the program more than two hours. Notify the Problem Leader if it appears that the difficulty might delay the program for more than four hours. Notify the engineering, data, maintenance, instrumentation, chemistry and other groups if trouble persists more than a few hours. Repeat the notification at least twice each day until operations are normal. Notify both the chief of operations and the Problem Leader immediately if a health hazard or a serious equipment loss is involved. Notify the chief of operations or the Problem Leader before any major equipment change is made, except in the event of emergency.

6. Realize that chemistry, engineering, instrumentation, and other groups are, in one sense, service groups to the operating group. Expect prompt action from these groups on any request for information.

The chief or assistant chief of operations will personally coordinate trouble-shooting activities between various shift supervisors when trouble persists over a shift change; however, this does not relieve any shift supervisor of the responsibilities listed above.

3.5.42 Restrictions Imposed on Operating Personnel

From the above, it is evident that the first responsibility for correction of operational difficulties rests upon the operating personnel, and in particular with the shift supervisor. However, there are very definite restrictions which must be imposed upon the operating group, and these restrictions are summarized as follows:

1. Run conditions must not be changed from chemical and engineering flowsheet conditions except with permission of the individuals concerned (the chief of operations or the Problem Leader). This does not preclude changes of very short duration which might be helpful in the event of trouble (such as temporarily increasing the scrub rate to regain hydraulic equilibrium).
2. Certain adjustments to instruments must be made only with the approval of the chief of operations or the Problem Leader.

Information on necessary changes made to equipment must be conveyed in writing to every member of the pilot plant organization.

3.5.43 Responsibilities of Groups and Individuals Other Than the Operating Group

The bulk of pilot plant difficulties can be attributed to deficiencies in engineering (including design, instrumentation, maintenance, and construction) and chemistry (including analytical and data analysis). For this reason it is important that each operating difficulty be studied by engineering, maintenance, instrumentation, chemistry, and data personnel. Specific responsibilities of these people in the event of serious difficulties are to:

1. Become thoroughly familiar with all circumstances of the operating difficulty.
2. Supply quickly all information requested by the shift supervisor.
3. Attempt to determine if the operating difficulty can be attributed to the phase of work for which some specific individual is responsible. (For instance, the chemist would consider whether trouble could be attributed to chemistry.)
4. Transmit to the chief of operations and the shift supervisor specific recommendations in writing for any action which it is felt might help in the rectification of the difficulty. Any such recommendation should be coordinated, if possible, with other groups before submission. The chief of operations and the Problem Leader should be advised of any strong recommendations which are rejected by the shift supervisors.

3.5.44 Restrictions Imposed on Other Groups

All physical measures taken to restore normal operation should be performed under the direction of the shift supervisor. No experimentation or corrective action to improve equipment operation should be undertaken by an individual without the knowledge and consent of the shift supervisor.

4.0 PILOT PLANT INFORMATION AND TECHNIQUES

The following sections describe pilot plant policies, procedures, and techniques which were developed over a several-year period of pilot plant operation. The ORNL Standard Practice Procedures Manual gives Laboratory policy and procedures for administration of property and personnel. The information in the following sections is intended to supplement the Laboratory procedures at the working level. Two main subjects are covered: (a) how the pilot plant group works with other groups, such as analytical, maintenance, health physics, and other Chemical Technology Division personnel, and (b) how members of the pilot plant group work with each other, including such topics as communications, training, overtime, etc.

4.1 Analytical Services

All analytical work, including analysis of routine samples, specialized analyses, and development of new analytical methods and instruments, is done by the Analytical Chemistry Division. Certain samples requiring highly specialized equipment not available at ORNL are sent to Y-12 or K-25.

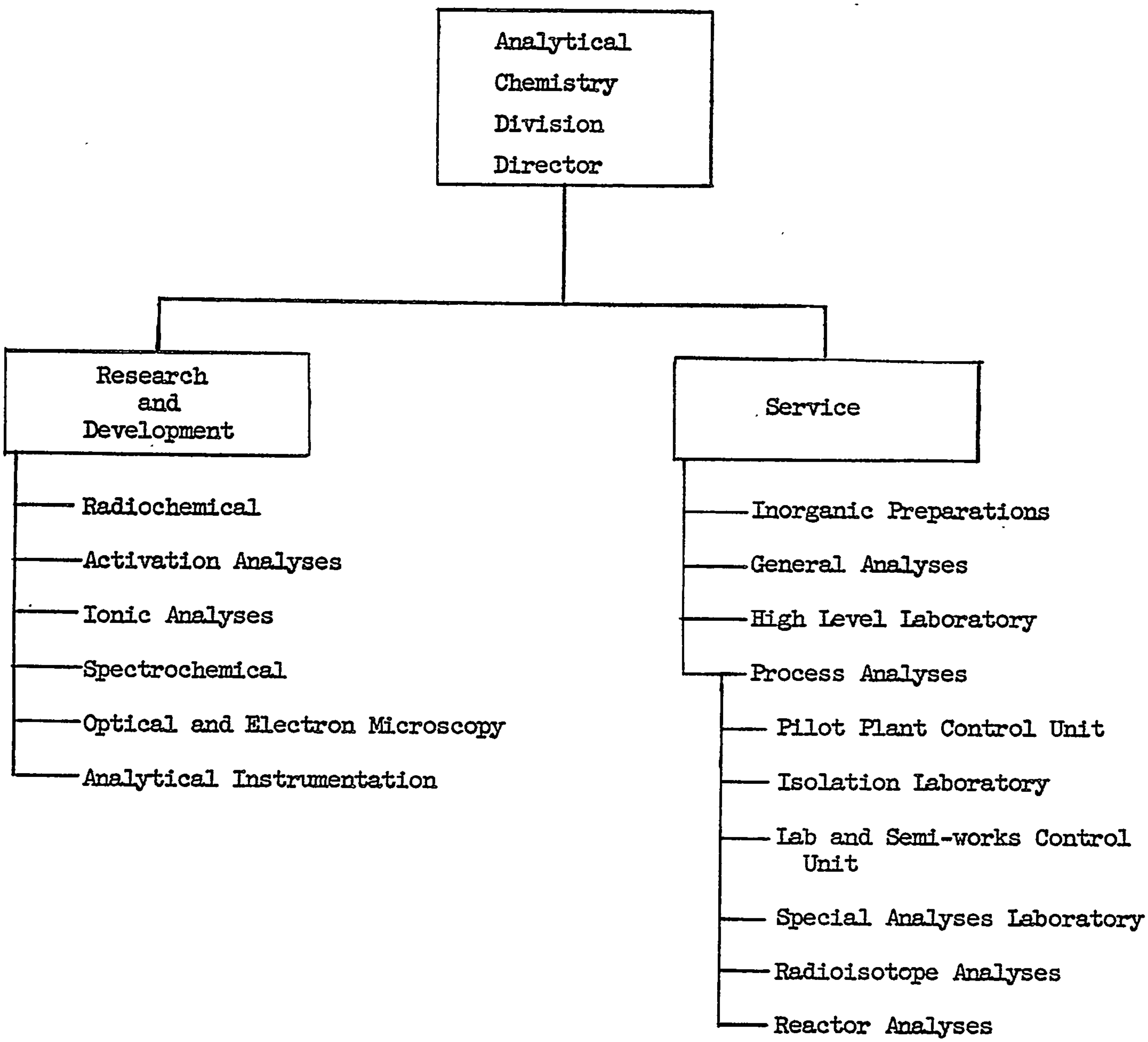
At ORNL, the Analytical Chemistry Division has six research and development groups and nine service groups (Fig. 4-1). Most pilot plant analyses are made by one or more of the process analyses groups, although many analyses are performed by the research and development groups, principally radiochemical, ionic, and spectrochemical.

A typical pilot plant, such as Thorex, requires 2,000 to 4,000 analyses per month, at a cost of about $20,000 per month or a quarter of a million dollars per year. A typical pilot plant spends about 20 per cent of its operating budget for analytical services. To further illustrate the magnitude of analytical costs for a pilot plant engaged in research and development, for each member of the Pilot Plant Section that the pilot plant supports, it will support an analyst in the laboratory. If the pilot plant is engaged in production type of operation, fewer analysts will be required because fewer samples (only those necessary for process control) will be taken, and this will decrease the cost to about 10 per cent of the operating budget.

Not only is the cost of analytical services an important facet of pilot plant management, but the success of the pilot plant may very well hinge on the relation between the pilot plant and analytical groups. Prior to startup of a new pilot plant, the Analytical Chemistry Division will need to know the types and numbers of analyses to be submitted, the solution compositions, the accuracy required, the time allowed for analysis, and the radiation level of the samples. They will also need to know the operating schedule of the plant, whether it will operate 24 hours a day, seven days a week or five days a week, the number of runs to be made per month, and the radiation exposure of the feed (how many runs with nonirradiated feed, spiked feed, and irradiated feed). All this information is

Fig. 4-1

Analytical Chemistry Division Organization



required to establish an analytical group (if one is required) or to schedule the analyses for an existing group, to determine if the analytical methods are adequate or if new methods will have to be developed, and to train the analytical personnel. All this takes time, and the sooner that the pilot plant informs the Analytical Chemistry Division of the anticipated needs, the better off the pilot plant will be. The Analytical Chemistry Division can also assist the pilot plant in planning sampling schedules and techniques. The pilot plant will need to know the volume of sample required for analysis, the type of sample bottle required, and whether or not special handling (such as centrifuging the sample, keeping the sample hot, etc.) will be required.

After startup and smooth operation of the plant has been achieved, the pilot plant will need to keep close liaison with the analytical groups. Minor problems occur every day and these must be resolved quickly. Operators will make mistakes, giving the wrong codes, switching samples, taking two-phase samples, etc., and analytical results will be out of line from previous results, rechecks of previous samples on a new set of samples will be required, the analytical results will be reported late, etc. Occasionally, special problems involving personnel or analytical methods will arise, and these will require the personal attention of the Problem Leader. Thus, the Problem Leader needs to establish routine procedures for handling the recurring problems, and give personal attention to improving relations (from the standpoint of both groups).

4.1.1 The Organization of a Typical Pilot Plant Analytical Control Unit

The Building 3019 control unit has 20 people, of which 7 are chemists and 13 are technicians. One chemist is the unit supervisor; one or two other chemists are used for special problems. There are four shifts, one of which is off each day, and each shift has a chemist as supervisor and two technicians. Three chemists and five technicians work straight days. This unit analyzes routine samples for the Thorex Pilot Plant and the Metal Recovery Plant and does miscellaneous analyses for other groups. Normally, the unit makes about 4,000 analyses per month; each analyst averages 16 analyses per day (average time of 30 minutes per analysis).

The shift personnel analyze samples that are submitted as "rush" samples (results are required within 8 hours), and the straight-day personnel analyze samples that have no priority. The number of shift personnel is kept as low as possible consistent with the requirements of the Thorex Pilot Plant and the Metal Recovery Plant. The straight-day personnel have a backlog of samples and by not being interrupted with "rush" samples, they can mass-produce analyses at low cost.

4.1.2 Liaison between the Analytical and Pilot Plant Groups

On shifts, the shift supervisor in the pilot plant keeps the analytical shift supervisor informed of the analytical requirements. At the beginning of the shift, the pilot plant shift supervisor gives the analytical shift supervisor an estimation sheet on which the type and number of samples to be taken on that shift are listed. Also, the priority of the samples is indicated on the sheet. Throughout the shift the two supervisors contact one another, reporting results, and checking on various problems, such as miscoding of samples, poor samples, etc.

The supervisor of the control unit maintains liaison with the pilot plant groups on the day shift by personal contact with members of the groups.

A meeting of supervisory personnel from the Analytical Chemistry Division and pilot plant problem leaders is held at a definite time every other week to discuss their unresolved problems and to take any necessary remedial action. Even though there is a lot of informal daily coordination between pilot plant and analytical shift personnel, there are occasional complaints from both groups. Pilot plant personnel generally complain of delay in receiving analytical results or of inaccurate results, while analytical personnel frequently complain of sloppy techniques of sample submission, nonuniform, or nonrepresentative solutions, and the contamination of the analytical laboratory by pilot plant personnel. In these weekly meetings both pilot plant and analytical personnel present their complaints completely and quantitatively by reference to specific samples and specific incidents. Each complaint is discussed in detail, and agreement is usually reached as to whether the complaint is justified. If justified, a specific course of action to prevent recurrence of the complaint is agreed upon. In cases where it is difficult to determine if the complaint is legitimate, a specific action is agreed upon to determine if the complaint is justified. Numerous specific details have been worked out in these meetings to the satisfaction of both groups, and, as a result, intra-group cooperation has improved.

4.1.3 How Samples Are Submitted and Analyzed and Results Reported

Before the Test Facility was put into operation, several meetings were held with Analytical Chemistry Division supervisory personnel to mutually agree on the establishment of an analytical control unit for the Test Facility. After the unit was established, procedures for maintaining liaison between the groups, for coding and submitting samples, for reporting results, for storing and disposing of samples, and for sending special samples to Y-12 were published.(10) These procedures were very similar to those used in the Purex Pilot Plant, and were easily followed by both the Test Facility and analytical personnel.

The Thorex Pilot Plant has similar procedures. The pilot plant operator delivers the samples to the Sample Storage and Dilution Room in Building 3019, places the samples on a shelf, and presses a buzzer to call the analytical shift supervisor. The shift supervisor monitors the samples with a health physics instrument to determine the radiation level, and, if he has any questions about the samples or the sample codes, he asks the operator for clarification.

The samples are classified into three groups: flowing stream, composite, and solution makeup samples.

The operator does not submit a request sheet with flowing stream samples because the Laboratory has special forms for logging in these samples. The operator records the sample codes on this form, which has spaces for 18 samples, corresponding to the 18 spaces for sample codes on the data report sheet.

For composite and solution makeup samples, the operator fills out a standard stores-stock form, "Request for Control Analyses". The operator gives the sample codes, analyses requested, estimations, and approximate composition of the solution. He also indicates if the sample has a priority. The shift supervisor records the time that the samples are received in the laboratory.

After the analytical shift supervisor has received the samples, he prepares work sheets for the requested analyses. The work sheets are given to as many analysts as necessary to perform the work. He supervises the technicians to make sure that they are following the analytical procedures for analysis, and he takes back the work sheet after it and the analysis have been completed. If the calculations are correct, the supervisor posts the results on a report sheet, which is later sent to the pilot plant. If it is a rush or priority analysis, the supervisor phones the results to the pilot plant.

If there are discrepancies in the result or if the result appears to be out of line, the supervisor immediately prepares another work sheet and assigns the sample to another technician, who makes another analysis and submits the result to the supervisor. If this check analysis is unsatisfactory, a new set of samples will be requested. When the pilot plant requests check analyses, the mechanics of handling these are the same as if the analytical supervisor requests the check.

After the samples have been analyzed and the results reported, they are stored by the laboratory. The samples may be disposed of in two ways: solution makeup samples are stored for a few days and are then discarded; other samples are stored until the pilot plant data or operations groups send a note to the supervisor directing him to dispose of samples no longer needed. Certain samples, such as feed and product samples, are stored for one to two weeks as reference samples.

4.1.4 A Discussion of the Most Common Analytical Problems

Many of the problems that upset an otherwise smoothly running analytical group arise through misunderstanding and failure to follow procedures. These were discussed in Section 4.1.2. For best service from an analytical group, the Problem Leader should do all he can to promote a friendly atmosphere and a generally cooperative attitude in the pilot plant as well as in the analytical laboratory.

The major cause of poor analytical service is the overloading of the control unit with more samples than the technicians can analyze in the time alloted. Pilot plant personnel are very prone to submitting many samples on a rush basis, and when too many are submitted, the efficiency of the laboratory and the morale of the technicians are seriously affected. If all the analytical personnel are assigned to work at the time rush samples are received, someone must stop his routine work and do the analyses with higher priority. If the technician is making, for example, colorimetric uranium determinations, he must do the entire analyses from the beginning again because these solutions fade on standing. In some cases, the entire group may be working on rush analyses, and if more are received, the shift supervisor must contact each group that submitted samples to determine which analyses take priority.

Occasionally a type of analysis or procedure goes out of control in the laboratory through carelessness, lack of attention, or instrument failure. If this happens to the colorimetric method for uranium analysis, the laboratory efficiency decreases. About 10 per cent of the total determinations made by the Building 3019 Control Unit are made by a colorimetric method. Controls are run daily on every shift by this method to determine that everything is in order. If the results are out of limit, the supervisor investigates the method to determine if the trouble is due to reagents, instrument failure, contamination, or some other cause, and, after the information is evaluated, corrective measures are taken.

Samples which are not homogeneous or representative of the solution sampled cause difficulties. Time is lost in analyzing these samples, and the poor results cause complaints back and forth between the operating and analytical groups. Some solutions, however, are troublesome because of the characteristics of the solution itself, for example, plating out of fission product activities on the wall of the sample bottle. These solutions require immediate treatment to prevent the plating out. Unreliable results are often obtained with this type of solution.

4.1.5 Analytical Cost Studies

Several studies of analytical costs have been published[11, 12, 13] by the

Pilot Plant Section, the most recent being in ORNL CF-55-6-171 for the period of February 1954 through June 1955.(14) Based on this and previous studies, the following general conclusions and recommendations on Chemical Technology Division analytical costs were reached.(15)

Conclusions

1. About 90% of Chemical Technology Division samples are analyzed in three laboratories: Special Analyses Laboratory, Pilot Plant Control Unit, and Lab and Semiworks Control Unit, referred to as routine laboratories. These laboratories do not normally analyze samples for other divisions. The only method of controlling our analytical cost in these laboratories is to control the number of technicians and supervisors assigned to them.

   Analytical costs in these laboratories <u>cannot</u> be controlled adequately by attempting only to control the number of samples submitted; this is a firm conclusion, but is somewhat difficult to analyze, since it deals with considerations such as analytical personnel's desire to provide sufficient personnel to give fast, accurate service, and our difficulty in controlling the number of samples submitted. The control of costs in these laboratories is controlling in the over-all analytical cost picture.

2. About 7% of the Chemical Technology Division's analyses are made by the Radioisotope Analyses Laboratory. The cost of analysis in this laboratory can be controlled by:
   a. Reducing the number of analyses.
   b. Making firm arrangements with the unit supervision concerning how many people, on the average, should be budgeted for the work (in order that standby time will be a minimum).

3. About 3% of the Chemical Technology Division samples are analyzed in seven laboratories: General Analyses, Spectrochemical, Reactor Analyses, Activation Analyses, Radiochemical, Ionic, and Optical and Electron Microscopy. These laboratories do more specialized analyses, and the average cost per analysis is higher than that from the routine labs. The cost of analysis in these seven laboratories can be reduced as follows:
   a. By reducing the number of analyses submitted. Only samples that cannot be analyzed by the routine laboratories should be sent to these. Many types of samples which initially are sent to these laboratories during early stages of process development programs should be turned over to the routine laboratories as soon as routine procedures are developed. In some cases, the required specialized equipment precludes doing the work in the routine laboratories, but in many cases this specialized equipment can be procured and operated by the routine laboratories.
   b. In the event that analytical development, rather than more routine sample analysis, is required from these laboratories, firm arrangements about the scope of the development, the manpower, and cost should be made.

4. The Chemical Technology Division supports an average of nine administrative and research personnel per month, which is 16% of the number supported for analysis and specific development work. This cost can be reduced by the Analytical Chemistry Division by budgeting separately for an analytical research program and not prorating this cost to the research divisions.

Recommendations

1. Chemical Technology Division costs should be controlled by having firm agreements with the Analytical Chemistry Division concerning the total number of analytical people to be supported by the Chemical Technology Division. This agreement should be detailed, based on the number of analysts and supervisors that would be supported by each section. To this basic support for direct labor, 16% would be added for administrative and general research support, until such time as general research is budgeted separately by the Analytical Chemistry Division. This procedure is now in effect and seems to be working satisfactorily. The total number of people should be adjusted periodically, probably twice each year.

2. All Chemical Technology Division work should be consolidated into as few laboratories as possible. The Analytical Chemistry Division should be supported in their efforts to obtain adequate space in Building 4500 for consolidation. Only highly specialized work, such as spectrographic, neutron activation, and electron microscopy, should be done in other laboratories.

3. Chemical Technology Division personnel should be educated on analytical costs so that they will be more judicious in their selection of analyses, number of samples submitted and their choice of laboratories for doing their work.

4.1.6 How Analytical Costs Are Charged and Reported

Analyses are charged for on a man-hour basis for each result reported; i. e., if one sample is submitted for one analysis, the requestor would pay for only one even though the laboratory may make four determinations to arrive at one reported result. If two samples are submitted for the same analysis, two analyses are charged for because two results would be reported. Similarly, if three determinations are requested on one sample, three would be charged for.

The man-hour charge is obtained from a schedule of charges published by the Analytical Chemistry Division. This schedule lists 200-300 analyses which can be done by the various analytical groups. The analysis time for a single sample and the analysis time for each additional sample are listed. If a single sample is submitted for uranium analysis by the colorimetric method, 0.5 man-hour would be charged for the analysis, and if more samples are submitted along with this first sample for the same analysis, 0.3 man-hour would be charged for each additional sample. If TBP extraction were required to prepare the sample, then according to the schedule 1.0 man-hour would be charged for the first sample and 0.5 man-hour for each additional sample. This schedule is based on normal samples requiring very little preparation. If a difficultly soluble sample is submitted, for example, additional time would be charged for sample preparation.

On the twenty-third day of each month, each analytical supervisor calculates the charges for the services of his group during the preceding month. The man-hours charged to each program that submitted samples to his laboratory are totalled. This is the direct analytical labor time devoted to the analysis of samples. To each of these programs, the supervisors' time is prorated based on the total man-hours of direct labor. If development work was done for a program (contracted by mutual agreement between the requestor and the analytical group supervisor) the number of man-hours devoted to the development work is charged to the requestor. The total number of man-hours devoted to analysis for all accounts is subtracted from the total number of man-hours of technician labor available in the laboratory group; this is called standby time and is prorated to all programs the same as supervisory labor. This information is transmitted to the Analytical Chemistry Division office, where the information from all the groups is consolidated and the charges for each program are calculated. These charges are reported on a form (Fig. 4-2) to the Chemical Technology Division office, where the costs, cost per analysis, etc. are calculated and transferred to another form (Fig. 4-3). This information is sent to all sections.

In general, routine analyses, like uranium, nitric acid, gross beta, and gross gamma, cost about $5 each; more difficult analyses, radiochemical and spectrographic, cost about $10 each; and highly specialized analyses, neutron activation, electron microscopy, etc., cost $20-$100 each.

Fig. 4-2

ANALYTICAL CHARGES

FOR MONTH OF May, 1956

CHARGE 3370—		GENERAL ANALYSES		SPECTRO-CHEMICAL ANALYSES		ANALYTICAL INSTRU-MENTATION		REACTOR ANALYSES		ISOLATION LABORATORY		PILOT PLANT CONTROL UNIT		ACTIVATION ANALYSES		SPECIAL RADIOCHEM. ANALYSES		IONIC ANALYSES		OPTICAL AND ELECTRON MICROSCOPY		LAB & SEMIWORKS CONTROL UNIT		RADIOISOTOPE ANALYSES				TOTAL	
		Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%	Man hrs	%
11	Analysis									125.9												7							
	Development									0												0							
	Supervision									20.1												1							
	Standby									16.9												1							
	Total									162.9												9							
	No. of Analyses									187												19							206
	% Charge									.843												.058							.901
	$ Cost																												$811
	$ per Analysis																												
13	Analysis									26.9																			
	Development									0																			
	Supervision									4.3																			
	Standby									3.6																			
	Total									34.8																			
	No. of Analyses									48																			48
	% Charge									.179																			.179
	$ Cost																												$161
	$ per Analysis																												
17	Analysis			30						97.7						0		6		32				0					
	Development			0						0						8		2		0				0					
	Supervision			4.1						42.8						1		2		2				0					
	Standby			5.1						51.4						1		1		0				31					
	Total			39.2						191.9						10		11		34				31					
	No. of Analyses			0						166						0		3		0				0					169
	% Charge			.216						.992						.047		.055		.197				.155					1.662
	$ Cost																												$1496
	$ per Analysis																												1.047

Fig. 4-3

CHEMICAL TECHNOLOGY DIVISION

ANALYTICAL COSTS

FOR MONTH OF August, 1955

CHARGE 3370-	GENERAL ANALYSES		SPECTRO-CHEMICAL ANALYSES		ANALYTICAL INSTRU-MENTATION		REACTOR ANALYSES		ISOLATION LABORATORY		PILOT PLANT CONTROL UNIT		ACTIVATION ANALYSES		SPECIAL RADIOCHEM. ANALYSES		IONIC ANALYSES		OPTICAL AND ELECTRON MICROSCOPY		LAB & SEMIWORKS CONTROL UNIT		RADIOISOTOPE ANALYSES		DEVELOPMENT		TOTAL ANALYSES		TOTAL COST	COST PER ANALYSIS*
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	%	$	#	%	$	$
-6			16	0.218					14	0.082	1325	7.508											207	3.638			1562	11.486	15,316	9.80
-49			40	0.348					55	0.245	2848	10.026									16	0.115	37	0.250			2996	10.984	14,697	4.90
-99									98	0.885																	98	0.885	1,197	12.21
Total P.P.			56	0.566					167	1.222	4173	17.534									16	0.115	244	3.888			4656	23.325	31,210	6.70
-9			36	0.185					371	1.158											83	0.659					490	2.002	2,679	5.47
-11							23	0.158	9	0.128							8	0.108	DEVT	0.058	33	0.230			0.058	78	73	0.624	835	11.44
-13			8	0.038																	79	0.528	108	1.540			195	2.106	2,817	14.45
-14	20	0.800	4	0.060					342	1.558																	366	2.418	3,285	8.84
-17			4	0.016					157	0.753					156	0.333					7	0.061					324	1.163	1,556	4.80
-20																					184	0.904					184	0.904	1,210	6.58
-37									4	0.069																	4	0.069	92	23.00
-38			6	0.196					65	0.490									DEVT	0.491					0.491	657	174	2.377	3,180	18.28
-52			16	0.359					142	0.889			103	1.691							462	2.490	67	0.501			738	4.742	6,345	8.60
-54			6	0.517							51	0.503							DEVT	0.131	375	1.241			0.131	175	381	1.758	2,352	6.17
-60			15	0.087					2	0.035											15	0.107	83	0.509			115	0.738	987	8.58
-66									109	0.414																	109	0.414	554	5.08
-67									25	0.151											12	0.077					41	0.250	334	8.15
-91	2	0.020							64	0.298	4	0.022					84	0.911			24	0.253	30	0.167			204	1.649	2,206	10.81
-95	1	0.020																									1	0.020	27	27.00
-96									15	0.076											14	0.077	56	0.373			85	0.526	704	8.28
Total C.D.	23	0.840	95	1.458			23	0.158	1305	6.019	55	0.525	103	1.691	156	0.333	92	1.019	—	—	1288	6.627	344	3.090			3484	21.760	29,114	8.36
-8																					33	0.146					33	0.146	195	5.91
-15									633	2.675											25	0.138					658	2.813	3,764	5.72
-18																					26	0.152					26	0.152	203	7.80
-21																					21	0.115					21	0.115	154	7.33
-75																					139	0.353					139	0.353	472	3.40
-82																					1	0.015					1	0.015	20	20.00
-87																			DEVT	0.069	10	0.077			0.069	92	264	1.581	2,115	8.01
-87-1273			8	0.348					252	1.455			2	0.049							157	0.636					165	0.984	1,317	7.98
-87-1274																					11	0.054					11	0.054	72	6.54
-92									20	0.059											103	0.445					123	0.504	674	5.48
-97									6	0.018											32	0.152					115	0.664	888	7.72
-15-1344							77	0.494	18	0.083																	18	0.083	111	6.17
-15-1352									49	0.320																	49	0.320	428	8.73
-6-1359											28	0.087									133	0.666					161	0.753	1,007	6.25
Total U.O.			8	0.348			77	0.494	978	4.610	28	0.087	2	0.049							691	2.949					1784	8.537	11,422	6.41
Development %																									0.749					
Development $																										1,002				
Analyses TOTAL	23	0.840	159	2.372			100	0.652	2450	11.851	4256	18.146	105	1.740	156	0.333	92	1.019			1995	9.641	588	6.978			9924	53.622	54,371	72,748
TOTAL COST*		1,124		3,173				827		15,857		24,279		2,328		446		1,363				12,967		9,337				71,746		
COST PER ANALYSIS		48.87		19.96				8.27		6.47		5.70		22.17		2.86		14.81				6.50		15.88						7.33

*Overhead at ___ %

4.2 Budgeting and Cost Accounting

Budgeting, or the preparation of a financial plan for a program, and program planning for a period of one to three years must be done concurrently, for one cannot exist without the other. Although the Section Chief and Division Director carry the burden of submitting budgets to the ORNL budget office and the Atomic Energy Commission for approval, the Problem Leader has a serious responsibility for preparing the budget estimate and controlling expenditures within the budget.

Two types of money, capital and operating, are budgeted. Capital funds are described and the procedural details for submitting requests for capital funds are described in the ORNL Standard Practice Procedures Manual. This section presents operating budgets and accounting for expenditures of operating funds.

4.2.1 Mechanics of Budget Submission

The Laboratory is informed by the Commission on the programs that the Commission expects the Laboratory to pursue in the succeeding year. The program assumptions are transmitted to the Section Chiefs, who discuss these problems with the Problem Leaders, and a budget estimate, money and manpower, is prepared for periods of up to three fiscal years. The estimate is forwarded to the Division Director, who has the requirements of all four sections consolidated on one sheet. The Division Director and Section Chiefs meet to adjust the budget until the requirements are unified and agreeable to the sections and the budget is at a reasonable level. The budget is then sent to the ORNL budget office.

The budget office consolidates the budgets from all ORNL divisions and presents the consolidated budget to Laboratory Management. After Management studies the budgets, the Division Directors are called in for consultation and are asked to explain the Division's responsibility in each program. Management may adjust the budget as seems advisable, and, after all programs are accepted by Management, detailed write-ups are prepared for each program and bound in a "Gray Book". This, the formal laboratory budget proposal, is submitted to the AEC for approval, who compiles the budgets from all facilities for submission to the Bureau of Budgets. The Bureau submits the AEC budget to Congress for approval.

4.2.2 Preparation of Operating Budgets

Before a problem leader can prepare an operating budget estimate, he must have a program plan for the period to be budgeted. For a pilot plant, it must be determined whether the program will be all research and development, semiproduction, or all production, because the type of plant operation will affect the cost of the program and the amount of manpower required. It costs more to operate a pilot plant to obtain plant design data than it does to operate the plant solely to process and recover valuable materials. It also requires more manpower to do development work. For example, the Thorex pilot plant program assumes research and development work for one fiscal year, about half research and half production the second fiscal year, all production the third year; the fiscal budgets for these three years are $1,026,000, $980,000, and $720,000, respectively.

After the type of operation has been established, the second step in preparing a budget estimate is to develop a month-by-month program for the first fiscal year and to estimate the pilot plant manpower requirements for each month (see Fig. 4-4).

Fig. 4-4

Operating Budget Preparation

1. Summary of Man-Power and Money Required

Month	FY 1956			FY 1957			FY 1958		
	Man-Months		Cost	Man-Months		Cost	Man-Months		Cost
	Scient.	Tech.	$	Scient.	Tech.	$	Scient.	Tech.	$
July	13.5	12.5	85,000	10.0	15.0	115,000	-	-	-
August	13.5	12.5	89,000	10.0	15.0	115,000	-	-	-
September	10.5	12.5	94,000	10.0	15.0	114,000	-	-	-
October	10.5	12.5	97,000	10.0	15.0	114,000	-	-	-
November	4.5	0.5	48,000	6.0	4.0	66,000	-	-	-
December	10.5	12.5	91,000	6.0	4.0	66,000	-	-	-
January	11.5	15.5	90,000	6.0	4.0	66,000	-	-	-
February	11.5	15.5	85,000	6.0	4.0	66,000	-	-	-
March	11.5	15.5	85,000	10.0	15.0	64,000	-	-	-
April	11.5	15.5	85,000	10.0	15.0	65,000	-	-	-
May	11.5	15.5	90,000	10.0	15.0	64,000	-	-	-
June	11.5	15.5	87,000	10.0	15.0	65,000	-	-	-
Totals	132.0	156.0	1,026,000	104.0	136.0	980,000	108	168	720
Man-Power, Man-Years	11.0	13.0	-	8.7	11.3	-	9.0	14.0	-

2. Summary of Normal and Abnormal Costs

a. FY-1956:

Normal:	24 man-years at $30,000/man-year		=	$726,000
Abnormal:	Analytical costs	= $100,000		
	Construction	= 150,000		
	Major maintenance	= 35,000		
	Shipping costs	= 15,000		
	Total abnormal	=		300,000
Total Fiscal Cost			=	$1,026,000

b. FY-1957:

Normal:	20 man-years		=	$600,000
Abnormal:	Analytical costs	= $ 45,000		
	Construction	= 305,000		
	Shipping costs	= 30,000		
	Total abnormal		=	380,000
Total Fiscal Cost				$980,000

c. FY-1958:

Normal:	23 man-years	=	$690,000
Abnormal:	Shipping costs	=	30,000
Total Fiscal Cost		=	$720,000

Two types of manpower are budgeted, scientists and technicians. Scientists are technical personnel, while technicians are nontechnical (operators, technicians, draftsmen). Clerks, typists, or secretaries are not budgeted for as manpower. Technical personnel borrowed from other divisions should be shown on a separate line and should not be added to the pilot plant manpower. The total number of man-months required in a month (not including borrowed employees) is multiplied by a "cost-per-man-month" number to give the estimated normal operating cost for the month. Any abnormal costs anticipated for the month are added to the normal cost to give the total estimated cost for the month. The sum of twelve months' costs is the fiscal budget estimate. Although the budget shows normal plus abnormal costs as a total, the abnormal costs must also be reported separately in itemized form (description and cost of each item).

These steps of budget preparation should be repeated for the succeeding fiscal years; however, the budget for the third fiscal year should show the fiscal totals (scientist man-years, technician man-years, and money) rather than month-by-month totals.

The "cost-per-man-month" number is one-twelfth of the cost of a man-year, which is the average normal operating cost required to sustain a pilot plant person for one year. This cost is based on past experience in operating pilot plants, such as Thorex, Purex, and Metal Recovery, and is calculated by dividing the actual normal operating cost for a year by the actual number of man-years of pilot plant labor that had been charged to the pilot plant. For fiscal year 1955, the cost per man-year for the Metal Recovery Plant was $28,000 and for the Thorex Pilot Plant was $32,000. The Problem Leader should figure $30,000 to $35,000 as the cost per man-year, using about $35,000 for resesrch-type operation and about $30,000 for production-type operation.

4.2.3 Monthly Cost Estimates

In Section 4.2.2 budget estimates for fiscal years were calculated from manpower and cost per man-year numbers. This type of budgeting is suited for long-range budgeting, but not for estimating month-to-month operating expenses in a current fiscal year in which the pilot plant is being operated. For this purpose, a detailed estimate of the expenditures for each expense symbol* is made monthly. (Table 4-1 gives some suggestions and cost figures for estimation purposes.)

These estimates are entered on a pilot plant form (Fig. 4-5) and overhead costs are calculated from previously charged rates. When the operating costs (see Section 4.2.4) for a month are received, the actual costs are also tabulated on this form and are compared to the estimated costs. This aids in determining the actual rate of expenditure and comparing it to the estimated rate and minimizing overruns or underruns of expenditures. The estimates for the next month and future months should be revised as more information is developed concerning the anticipated operating costs.

4.2.4 Cost Accounting

The efficient management of any pilot plant program requires a systematic accounting of the money that is spent to operate the pilot plant. Two types of money are spent: capital and operating. The expenditures of both types are reported monthly

*Expense symbols are defined in the ORNL Standard Practice Procedures Manual

Table 4-1

SUGGESTIONS FOR ESTIMATING THE BUDGET AND SOME COST FIGURES FOR ESTIMATION PURPOSES

1. Miscellaneous Services

a. Labor

(1) Itemize miscellaneous maintenance requirements by crafts and the number of each craft required.
(2) Use $400/man-month for labor cost.
(3) Take 10% of craft man-months as foreman time.
(4) Use $600/man-month for foreman cost.

b. Materials

(1) Add up all known major commitments for materials to be purchased (specific items of unusual purchases), and average this cost for 12 months.
(2) Examine previous costs and if the situation will not change appreciably, use the previous cost data.

2. Equipment and Building Repairs

a. Labor and Materials

This is estimated the same as miscellaneous maintenance, except that this cost will fluctuate considerably more from month to month than miscellaneous maintenance, depending on the amount of maintenance required and the extent of modifications.

3. Rebuilding and Rearranging

a. Labor and Materials

This item is budgeted generally on the basis of major work order cost estimates for the fiscal year.

4. Protective Clothing

Use the following schedule:

Type of work	Clothing Requirements	Cost/Man-Month
No contamination	Occasionally wears protective clothing	$ 5
"Little" contamination	Changes every day	20
"Heavy" contamination	Changes every day	30

Table 4-1 (Cont'd)

5. Miscellaneous Services

On major problems, such as Metal Recovery or Thorex, this cost will run from \$100 to \$200 per month for labor and materials.

6. Analytical Services

a. Labor

Labor can be estimated either on a man-month basis or on the number of analyses.

(1) Man-Month Basis
The number of man-months x \$600 = total labor cost.

(2) Number of Analyses Basis
The average labor cost per analysis by laboratories is approximately as follows:

Type of Analysis	Cost/Analysis, \$
Routine (uranium, gross β, gross γ, nitric acid)	3
Radiochemical	5
Spectrographic	5
Neutron activation	50
Electron microscopy	50

Therefore, estimate the number of samples to be submitted by types of analysis per month, and this number times the above labor cost is the cost for analyses only. To this must be added costs for specific development.(Specific development is figured on a man-month basis, and is negotiated with the Analytical Chemistry Division.)

b. Analytical Materials

Use 10% of the labor cost.

7. Miscellaneous Supplies

This item has to be budgeted for on the basis of estimated purchases for such items as chemicals, stationery, laboratory supplies, instrument charts, small tools, etc.

Table 4-1 (Cont'd)

8. Pilot Plant Labor

This item is budgeted on the basis of $400/man-month for operator labor and $600/man-month of technical labor.

9. Sundry

The major cost item in this category is transportation costs for fuel. Other items, such as payments for equipment or travel expenses, may be charged to sundry expenses occasionally, but they are budgeted as other expenses. Sundry expenses usually are less than $1,000 per month.

10. Engineering Services

This item is usually budgeted on the basis of work order estimates.

11. Worked Materials

Worked materials should be budgeted on basis of charges as shown on previous operating reports.

12. Expense Allocation

Multiply the total labor expense by 65%.

13. Health Physics

Multiply the total labor expense by 7%.

14. Director's Department

Multiply the total labor expense by 3%.

15. Chemical Technology Division Distributed Costs

Multiply the total labor expense by 3%.

Fig. 4-5

ESTIMATED BUDGET REQUIREMENTS FORM
PILOT PLANT SECTION

Pilot Plant Problem Volatility
Account No. FY 1956

Symbol*	Description (L = Labor) (M = Materials)		July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June		Total
			Monthly Budget Requirement, $													
1	Miscellaneous Maintenance Service	L														
		M														
2	Equipment and Building Repairs	L														
		M														
9	Rebuilding and Rearranging	L														
		M														
1, 2, 9	Totals	L	—	—	—	50	100	300	4200	4200	5000	1400	1400	1400		18050
		M	—	—	—	10	10	30	100	400	600	100	100	100		1450
3	Protective Clothing	M	—	—	75	50	150	250	50	50	50	50	50	50		775
4	Miscellaneous Services	L	—	—	—	—	—	—	—	—	—	—	—	—		—
		M	50	50	50	50	50	50	50	50	50	50	50	50		600
4	Analytical Services	L	—	—	—	—	300	600	1800	1800	1800	1800	1800	650		10550
		M	—	—	—	—	30	60	180	180	180	180	180	65		1055
5	Miscellaneous Supplies	M	—	—	10	25	50	1500	2500	2500	1700	2100	2100	—		12485
6, 7, 10, 12	Pilot Plant Labor	L	900	1300	1900	2500	4300	6100	8100	8100	8100	8100	8100	5700		63200
8	Sundry	M	—	200	200	200	600	400	200	200	300	300	300	100		3000
13	Engineering Services	L	—	—	—	—	—	—	300	1200	600	—	—	—		2100
		M	—	—	—	—	—	—	—	30	10	—	—	—		40
Total Labor			900	1300	1900	2550	4700	7000	14400	15300	15570	11300	11300	7750		93900
Total Material			50	250	335	335	890	2290	3080	3410	2890	2780	2780	315		19405
Worked Material			—	—	1500	1500	1500	1500	2500	2500	2500	2500	2500	—		18500
% of Total Labor	Expense Allocation															
	Health Physics															
90	3340		810	1170	1710	2295	4230	6300	12960	13770	13950	10170	10170	6975		84510
	3370-1															
Contingencies																
TOTAL			1760	2720	5445	6680	11320	17090	32940	34980	34840	26750	26750	15040		216315
Credits																
Net Expenditures																

* Symbols have been changed since this form was devised. See "ORNL Standard Practice Procedures Manual".

by the accounting office to the Problem Leader. The types of reports differ. Capital expenditures are reported only as labor, material, and overhead expenditures; no breakdown of the expenses is given. Operating costs are reported each month, and these are given in detail by types of expense or expense symbols.

Operating expenses are reported each month on at least six different forms:

1. Materials purchase record
2. Accounts payable breakdown
3. Labor report
4. Operating report
5. Worked materials report
6. Work order report

From these six forms the Problem Leader can determine exactly where every dollar went.

The materials purchase report (Fig. 4-6) is received on about the fifteenth of each month. This report gives a detailed breakdown of the materials purchased during the previous month, and the breakdown is by expense symbols; i. e., for expense symbol 1, which is miscellaneous maintenance materials, the Problem Leader will receive a list of all the materials purchased on that symbol. For instance, the report will tell him the work order number that the material was purchased against, it will give him the item number of the material, what the material is, the number of units purchased, the cost per unit, the total purchase price, the badge number of the person who purchased the material, and the date it was purchased. This report is made for all materials, expense symbols 1, 2, 3, 5, and 9. It will also show him money that was paid for materials purchased from outside vendors; however, the material will be described by purchase order number, and not by the name of the item. One material symbol that is not reported on the materials purchased record is sundry materials, expense symbol 8. A breakdown of this type of purchase or expense is given on the accounts payable breakdown (Fig. 4-7) sheet, which is also received about the fifteenth of the month. This record will show what was paid out, i. e., the amount of money and for what purpose, either for travel expenses or shipping costs, or money that was paid to a vendor out of an accounts payable source. Thus, these two forms give a complete breakdown of all materials purchased for the previous month.

The third form, the labor report (Fig. 4-8) is also received on about the fifteenth of the month. This report gives a complete breakdown of the labor costs for the previous month. It lists the number of the department that charged for labor, the expense symbol, for instance, 1, 2, 4, or 9 that the labor was charged against; the number of dollars charged is shown broken down into hourly, weekly, and monthly labor, the total cost of labor charged by each department by expense symbol, and the total expenditure to date. From this report the Problem Leader can determine exactly what all labor costs him. He can determine his analytical labor expense, his maintenance expense, or his own department labor expense.

The information from these three reports is compiled into an operating report (Fig. 4-9) and the operating report is received on about the twentieth of each month. This report gives a breakdown by expense symbol of the labor and materials expenditures for the previous month. The form also shows the costs that were charged to the program for worked materials, health physics, expense allocation, prorated charges from the Director's Department, and prorated charges from the Chemical Technology Division. If costs were charged from Y-12 for isotopic assays, this cost is shown on the operating report. The operating report also shows the cost for all previous months in the fiscal year.

The worked materials report (Fig. 4-10) is received along with the operating report and gives a breakdown of the worked materials charges shown on the operating report. It shows the cost and kilowatt-hours of electricity, the costs for steam and air, tank farm costs, and the cost for decontamination services.

Fig. 4-6

FROM 08-01-55 TO 8-31-55

Materials Purchased

3807 MATERIAL

PAGE NO. 398

ACCOUNT NUMBER											CHARGED BY	
ACCOUNT	TYPE	1ST #	2ND #	WORK ORDER	CATALOG #	DESCRIPTION	UNIT	QUANTITY	UNIT VALUE	TOTAL VALUE	BADGE	DATE
3370	01	0006		A 002167 0	248 001792	Valve 08 1/2	EA	6	3.51	21.96	1646	8/05
3370	01	0006		A 002167 0	251 001850	PKNG 1/8	LB	1	1.95	1.95	1646	8/09
3370	01	0006		A 005749 0	243 003558	TUBING SS 1/4	FT	48	.32	15.36	1646	8/16
3370	01	0006		A 005749 0	244 003720	ELL SS 1 IN	EA	4	4.89	19.56	1646	8/01
3370	01	0006		A 005754 0	244 000930	ELL G 1/2 IN	EA	4	.09	.36	1646	8/16
3370	01	0006		A 005754 0	244 001480	ELL HI 1/2 IN	EA	2	.07	.14	1646	8/18
3370	01	0006		A 005754 0	244 001660	ELL HI 1/2 IN	EA	2	.07	.14	1646	8/18
3370	01	0006		A 005754 0	244 003875	NIPPLE 1/4x4	EA	2	.05	.10	1646	8/18
3370	01	0006		A 005754 0	244 003955	NIPPLE 1/2 X C	EA	6	.03	.18	1646	8/18
3370	01	0006		A 005754 0	244 004970	NIPPLE 1/2	EA	4	.10	.40	1646	8/18
3370	01	0006		A 005754 0	248 004515	TEE GALV 1/2	EA	1	.12	.12	1646	8/18
3370	01	0006		A 005754 0	248 005015	TEE MIS 1/2	EA	2	.10	.20	1646	8/22
3370	01	0006		A 005754 0	246 005015	TEE MIS 1/2	EA	1	.10	.10	1646	8/17
3370	01	0006		A 005754 0	247 001503	CONN 68x3	EA	4	.12	.48	1646	8/18
3370	01	0006		A 005754 0	247 002402	ROD-1-8-316	EA	4	3.33	13.32	1646	8/18
3370	01	0006		A 005754 0	247 005385	NIPPLE 1/4	EA	6	.05	.30	1646	8/18
3370	01	0006		A 005754 0	248 000260	VALVE 434	EA	4	3.19	12.76	1646	8/17
3370	01	0006		A 005754 0	248 000340	VALVE CB 1/2	EA	4	2.59	10.36	1646	8/17
3370	01	0006		A 005754 0	248 000960	VGATES 1/2	EA	1	3.28	3.28	1646	8/17
3370	01	0006		A 005754 0	248 001750	VALVE GS 1/2	EA	2	4.61	9.22	1646	8/22
3370	01	0006		A 005765 0	213 000565	COND FS1	EA	1	.67	.67	1356	8/17
3370	01	0006		A 005765 0	213 000585	COND FS12	EA	1	1.43	1.43	1356	8/17
3370	01	0006		A 005765 0	213 001675	COVER S232	EA	1	.32	.32	1356	8/17
3370	01	0006		A 005765 0	213 001738	COVER PS 57	EA	1	.14	.14	1356	8/17
3370	01	0006		A 005765 0	213 000498	RECEPT 70510	EA	2	1.20	2.40	1356	8/16
3370	01	0006		A 005765 0	219 000535	RELAY 700	EA	2	7.67	15.34	1356	8/16
3370	01	0006		A 005765 0	219 000790	SWTCH CR-1061	EA	1	3.09	3.09	1356	8/16
3370	01	0006		A 005765 0	220 002189	HEATER 9710	EA	1	.37	.37	1356	8/18
3370	01	0006		A 005765 0	230 000315	TUBE 6CS	EA	1	.49	.49	8095	8/19
3370	01	0006		A 005765 0	230 000345	TUBE 6PS	EA	1	.50	.50	8095	8/19
3370	01	0006		A 005765 0	230 000365	TUBE 6H6	EA	1	.53	.53	8095	8/19
3370	01	0006		A 005765 0	230 000385	TUBE 6J7	EA	1	.65	.65	8095	8/29
3370	01	0006		A 005765 0	232 004190	NAMEPLATE C	EA	2	.25	.50	8095	8/18
3370	01	0006		A 005765 0	232 004190	NAMEPLATE C	EA	31	.25	7.75	8095	8/19
3370	01	0006		A 005765 0	232 004190	NAMEPLATE C	EA	2	.25	.50	8095	8/16
3370	01	0006		A 005765 0	234 008775	METER 0-9A	EA	1	10.87	10.87	8095	8/09
3370	01	0006		A 005765 0	234 000810	METER 0-20A	EA	6	10.94	65.64	8095	8/09

Fig. 4-7

ACCOUNTS PAYABLE DISTRIBUTION

CHECK NUMBER	TYPE DIST	ACCOUNT NUMBER	TYPE	1ST NO.	2ND NO.	PURCHASE ORDER NO.	WORK ORDER NO.	DATE	AMOUNT	
35452	1891	3370	5	6		2 89815		8/31/55	40.00	
35452	1891	3370	5	6		2 89815		8/31/55	40.00 CR	
									CR*	
32889	1891	3370	8	6		SSO 17459		8/16/55	1931.56	
									1931.56 *	
32263	1891	3370	9	6		1 14443	A0057640	8/11/55	3.17 CR	
32263	1891	3370	9	6		1 14443	A0057640	8/11/55	65.55	
33572	1891	3370	9	6		1 14443	A0057640	8/19/55	7.96	
									70.34 *	
									2001.90 **	
	1887	3370	5	6		1 13530		8/31/55	429.00	
									429.00 *	
	1887	3370	8	6		784		8/31/55	450.00 CR	
									450.00 CR*	
									21.00 CR	
	1850	3370	5	6				8/08/55	10.80	RESEARCH MAT
									10.80 *	
	1850	3370	8	6				8/31/55	171.58	TRVL. SHANK
	1850	3370	8	6				8/08/55	150.88	TRVL. JACKSON
									322.46 *	
									333.26 **	
									2314.16 ***	

Fig. 4—8

OPERATING REPORT

WCX IBM 40-A

LABOR ONLY

3370 6
COST ACCOUNT OR DEPT.

DATE 9/30/55 PAGE NO. 1

CHARGED BY	CHARGED TO				AMOUNT - DOLLARS ONLY					
DEPT.	ACCOUNT	TYPE EXP.	FIRST NUMBER	SECOND NUMBER	MATERIAL	HOURLY LABOR	NON EXEMPT SALARIES	EXEMPT SALARIES	TOTAL THIS MONTH	FISCAL YEAR - TO DATE
3003	3370	1	6			1754		348	2102	4148
3008	3370	1	6							17
3011	3370	1	6			8			8	8
3016	3370	1	6			10		8	18	550
3062	3370	1	6							4
3075	3370	1	6			746		165	911	3445
1005	3370	2	6							5
3003	3370	2	6			959		295	1254	5796
3008	3370	2	6							9
3009	3370	2	6							7
3062	3370	2	6			212			212	770
3075	3370	2	6							5
3117	3370	4	6							353
3290	3370	4	6					10860	10860	30291
3420	3370	4	6					68	68	68
4435	3370	4	6				18		18	102
3370	3370	7	6			4779	1149	6000	11928	38416
2044	3370	9	6							20
3003	3370	9	6			2616		674	3290	9653
3016	3370	9	6			588		95	683	924
3062	3370	9	6			36			36	104
3370	3370	10	6					1011	1011	2150
3370	3370	15	6			185	37	150	372	2309
3370	3370	16	6					70	70	191
3370	3370	17	6					75	75	75
3370	3370	18	6			184	73	358	615	1242
3370	3370	28	6							30
3003	3370	2	6	1354		2			2	294
3062	3370	2	6	1354		72			72	72
3290	3370	4	6	1354				2687	2687	3244
3370	3370	7	6	1354			1303	623	1926	4408
3003	3370	9	6	1354		90		23	113	324
3370	3370	15	6	1354						90
3370	3370	16	6	1354			11	30	41	41
3370	3370	17	6	1354						18
TOTAL OF YOUR PAYROLL										
TOTAL CHARGED BY YOU TO OTHERS										
TOTAL CHARGED TO YOUR ACCOUNT										
$ TOTAL CHARGED YOU BY OTHERS										

Fig. 4-9

DISTRIBUTION		OPERATING REPORT - COST SUMMARY						FISCAL YEAR	COST ACCOUNT
H. K. Jackson J. L. Matherne C. W. Schersten W. H. Lewis 10		DEPT. Waste Metal Recovery Plant Operations						1955	3370-49
		COSTS							
		JULY JANUARY X	AUGUST FEBRUARY X	SEPTEMBER MARCH X	OCTOBER APRIL X	NOVEMBER MAY X	DECEMBER JUNE	TOTAL JULY-DEC.	TOTAL JULY-JUNE
MISCELLANEOUS	1L	16	169	269	236	113		5,474	
MAINT. SERVICES	1M	143	392*	398	381	39		4,227	
EQUIP. & BLDG.	2L	38	1,767	1,730	1,174	355		5,340	
REPAIRS	2M	26	1,203	676	1,033	1,021		3,916	
PRO. CLOTHING	3M	934	554	1,144	517	625		3,899	
MISCELLANEOUS	4L	5,139	4,941	5,098	4,927	3,381		32,488	
SERVICES	4M	440	446	551	835	687		3,888	
SUPPLIES	5M	523	36,975	4,212	9,002	1,029*		41,565	
ENGINEERING	6L	253		91	92	272		3,156	
SERVICES	6M								
DEPT. LABOR	7L	11,091	8,921	8,539	5,587	5,029		31,737	
SUNDRY	8M			262*	246			859	
REBUILDING &	9L	8,390	2,142	3,699	1,390	6,268		30,481	
REARRANGEMENT	9M	4,613	2,909	1,650	835	3,568		18,234	
SUPERVISION	10L	880	3,085	3,139	4,708	2,367		12,372	
SUPP. LABOR	14L								
TOTAL		32,596	62,720	31,144	31,361	23,071		199,240	
MEMO ANAL.CHEM. X-10	4	5,568	5,270	5,649	5,748	4,057		36,074	
MEMO ANAL.CHEM. Y-12	4								
MEMO REPRODUCTION	4	10	106		14	11		109	
MEMO PHOTOGRAPHY	4	1	11					27	
A LABOR DIRECT	1-2-9	8,444	4,078	5,908	2,884	6,736		41,295	
	4-6-7-10-14	17,473	16,947	16,867	15,628	11,424		81,357	
TOTAL		25,917	21,025	22,775	18,512	18,160		122,652	
B MATERIAL DIRECT	1-2-9	4,782	3,720	2,724	2,249	4,628		26,377	
	3-4-5-6-8	1,897	37,975	5,645	10,600	283		50,211	
TOTAL		6,679	41,695	8,369	12,849	4,911		76,588	
BASIC COSTS (A&B)		32,596	62,720	31,144	31,361	23,071		199,240	
EXPENSE ALLOCATION		15,935	12,797	14,446	11,667	11,470		78,299	
HEALTH PHYSICS		2,052	1,846	1,953	1,601	1,549		10,535	
SUB-TOTAL									
WORKED MATERIAL		3,877	4,490	4,781	4,882	5,412		29,316	
METALLURGY LABS									
TOTAL COST (GROSS)		56,455	83,526	54,426	51,096	43,038		328,152	
PRODUCTION									
UNIT COST									
F. Y. TO DATE		384,607	468,133	522,559	573,655	616,693		328,152	
% BUDGET EXPENDED									
F. Y. BUDGET									

*DENOTES RED FIGURE

Fig. 4-10

OPERATING REPORT

RAW AND WORKED MATERIALS DETAIL

FISCAL YEAR	COST ACCOUNT
1955	3370-49

UNIT		JULY / JANUARY	AUGUST / FEBRUARY X	SEPTEMBER / MARCH X	OCTOBER / APRIL X	NOVEMBER / MAY X	DECEMBER / JUNE	TOTAL JULY-DEC.	TOTAL JULY-JUNE
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q	8.50	8.50	8.50	8.90	8.90			
Tank Farm %	$	1,209	1,181	806	1,346	999		8,672	
	Q		22.10	26.60	16.30	20.30			
Equip. Decont.%	$		557	1,142	392	812		810	
	Q	2.08	2.28	1.96	2.06	1.99			
S.F. Mat'l Cont. %	$	127	144	140	130	144		1,172	
	Q	5.33	5.33	5.33	6.15	6.15			
Air %	$	171	214	180	184	192		1,665	
	Q	2,512	2,589	2,362	2,349	2,477		12,891	
Steam M-Lbs	$	1,635	1,702	1,721	1,829	2,117		10,847	
	Q	2,277	2,084	3,013	3,511	3,985		18,472	
Tr. Water M-Gal	$	252	257	290	378	491		2,116	
	Q	96	86	100	132	147		801	
Elect. M-KWH	$	483	435	502	623	657		4,034	
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
Total	$	3,877	4,490	4,781	4,882	5,412		29,316	
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								
	Q								
	$								

*Denotes Red Figure

GROUP WORKED MATERIALS AND RAW MATERIALS AND TOTAL EACH GROUP

The work order report (Fig. 4-11) is received on the tenth to the fifteenth of the month, and this form shows the labor and materials costs for each work order. The materials are itemized by expense symbol and by item number. The material is described; the number of units purchased, the unit cost, the total cost, and the total cost to date are itemized for each material. Labor is tabulated on this form by craft codes, i. e., the work order number is shown, the expense symbol, the department that did the work, the type of labor, (monthly is coded M, weekly is W, hourly is H) and the craft codes are shown. The number of man-hours charged by each craft, the cost per man-hour, and the total cost are itemized. In addition, the total number of man-hours charged to date and the total cost to date are shown.

All six of these forms should be scrutinized very closely by the Problem Leader. Many things can be determined from these forms, but probably the most important thing for the Problem Leader to determine is whether or not his expenditures are on schedule with the anticipated expenditures. If the Problem Leader does not do this, he may find after eight months of operation that he has spent his entire budget and has no more money to last him to the end of the year. Frequently, one can find mistakes on these forms, particularly on the materials purchased form, such as overcharging, or charges to the wrong code. Also, some people have a tendency to buy two or three times as much materials as they actually plan to use, and this type of person can be spotted by examining the quantities of materials purchased and the badge number. By eliminating over-buying, the Problem Leader can in many cases reduce his expenditures to a reasonable level.

After the Problem Leader receives these six forms, has scrutinized the costs, and is sure that he understands them all, he should tabulate the costs on a form (Fig. 4-12) that shows the expenditures for the previous months of the year and compare his expenditures with his anticipated budget for that month. Although budgets are made up and submitted at least twice a year, it is necessary for the Problem Leader to evaluate his budget status each month and revise his monthly estimates as he receives better information and knows more details about the operations. Only in this way can a Problem Leader stay within his budget for an entire fiscal year.

Fig. 4-11

WORK ORDER REPORT

Form No. WCX-IBM 47

FINAL

8-31-55
DATE

PAGE NO.

DIV.	ACCOUNT NUMBER ACCT.	TYPE	FIRST NUMBER	SECOND NUMBER	WORK ORDER NUMBER	CRAFT	DEPT.-ROLL OR MAT'L ACCT.	CATALOG NO. CLASS	SUB CLASS	ITEM NUMBER	MATERIAL DESCRIPTION	CURRENT MONTH QUANTITY OR HOURS *	UNIT OR RATE P/HR.	COST LABOR & MAT'L	TO DATE HOURS	COST LABOR & MAT'L
	3370	1	6		A 2166		INSTL LEAD SHIELDING IN BT-DECAY AREA									
	3370	1	6		A 2166						BAL. FWD. MAT.					125 83
	3370	1	6		A 2166						TOTAL MATERIAL					125 83
	3370	1	6		A 2166		3003M								40 00	141 00
	3370	1	6		A 2166	23	3003H	- WELDER							33 00	78 00
	3370	1	6		A 2166	28	3003H	- PIPEFITTER							34 00	80 00
	3370	1	6		A 2166	29	3003H								40 00	95 00
	3370	1	6		A 2166	33	3003H								4 00	10 00
	3370	1	6		A 2166	34	3062H								56 00	100 00
	3370	1	6		A 2166	36	3003H								2 00	4 00
	3370	1	6		A 2166	39	3003H								28 00	66 00
	3370	1	6		A 2166	41	3003H								68 00	162 00
											TOTAL LABOR				305 00	736 00
											TOTAL W. O.	CR		CR	305 00	861 83
	3370	1	6		A 2167		DECONTAMINATE CELL 4 B-3019									
	3370	1	6		A 2167						BAL. FWD/ MAT.					981 74
	3370	1	6		A 2167		3807	248		001792	VALVE GB 1/2	6	EA	21 06		
	3370	1	6		A 2167		3807	251		001850	PKNG 1/8	1	LB	1 95		
	3370	1	6		A 2167						TOTAL MATERIAL			23 01		1004 75
	3370	1	6		A 2167		3003M								27 00	92 00
	3370	1	6		A 2167	33	3003H								16 00	38 00
	3370	1	6		A 2167	36	3003H								10 00	24 00
	3370	1	6		A 2167	39	3003H								211 05	501 00
	3370	1	6		A 2167	41	3003H								20 00	48 00
											TOTAL LABOR				284 05	703 00
											TOTAL W. O.	CR		23 01	284 05	1707 75
	3370	1	6		A 5749		FAB 2 TONGS FOR THOREX SAMPLER									
	3370	1	6		A 5749						BAL. FWD. MAT.					80 06
	3370	1	6		A 5749		3807	243		003558	TUBING SS 1/4	48	FT	15 36		
	3370	1	6		A 5749		3807	244		003720	ELL SS 1 IN	4	EA	19 56		
	3370	1	6		A 5749						TOTAL MATERIAL			34 92		114 98

* TOTALS FOR HOURS ONLY

Fig. 4-12
OPERATING BUDGET ANALYSES FORM
PILOT PLANT SECTION

Pilot Plant Problem METAL RECOVERY PLANT
Account No. 3370-49 FY 1955
Month Dec % of FY complete 50

Symbol*	Description (L = Labor) (M = Materials)		Previous Months Costs, $ July	August	Sept.	Oct.	Nov.	Total Credits	December Costs, $ Budget	Actual	Credit	Expended This Month	Total through Dec. Net $ Expended To Date	% of Budget Expended	Total Estimated Remaining	Future Months Budget, $ Jan.	Feb.	March	April	May	June	Budget
1	Miscellaneous Maintenance Service	L	248	3291	6491	1904	780	7408	600	168	—	168	5474	62.3	3300	300	600	600	600	600	600	8774
		M	—	1193	5320	1162	233	3749	500	68	—	68	4227	97.7	100	100	—	—	—	—	—	4327
2	Equipment and Building Repairs	L	3564	798	688	127	73	—	—	90	—	90	5340	43.4	6900	—	1380	1380	1380	1380	1380	12240
		M	2911	1382	—	190	6	574	—	1	—	1	3916	34.2	7500	—	1500	1500	1500	1500	1500	11416
9	Rebuilding and Rearranging	L	—	6	—	14776	7112	—	6900	8587	—	8587	30481	65.4	16100	11500	4600					46581
		M	65	—	18	4017	9085	—	3000	5049	—	5049	18234	31.3	40000	6000	34000	—	—	—	—	58234
1, 2, 9	Totals	L	3812	4095	7179	16807	7965	7408	7500	8845	—	8845	41295	61.0	26300	11800	6580	1980	1980	1980	1980	67595
		M	2976	2575	5338	5369	9324	4323	3500	5118	—	5118	26397	35.7	47600	6100	35500	1500	1500	1500	1500	73977
3	Protective Clothing	M	747	600	773	1177	319	—	1000	283	—	283	3899	48.1	4200	1000	640	640	640	640	640	8099
4	Miscellaneous Services	L	30	40	32	—	—	—	50	—	—	—	102	25.4	300	50	50	50	50	50	50	402
		M	—	—	—	126	29	—	50	47	—	47	202	40.3	300	50	50	50	50	50	50	502
4	Analytical Services	L	8506	6172	5519	5552	3764	—	3000	2873	—	2873	32386	50.7	31450	4950	5300	5300	5300	5300	5300	63836
		M	1034	730	649	634	393	—	300	246	—	246	3686	54.0	31450	500	530	530	530	530	530	6836
5	Miscellaneous Supplies	M	11210	12122	9132	4685	1771	644	2000	3289	—	3289	41565	46.4	48000	8000	8000	8000	8000	8000	8000	89565
6, 7, 10, 12	Pilot Plant Labor	L	9289	9765	10953	7163	3045	—	6000	8654	—	8654	48869	46.7	55800	10000	9400	9400	9000	9000	9000	104669
8	Sundry	M	141	74	547	10	87	—	100	—	—	—	859	22.2	3000	500	600	500	500	500	500	3859
13	Engineering Services	L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Labor			21637	20072	23683	29522	14774	7408	16550	20372	—	20372	122652	51.9	118850	26800	21330	16730	16330	16330	16330	236502
Total Material			16108	16101	16439	12001	11923	4967	10450	8983	—	8983	76588	41.9	106250	16150	45220	11220	11220	11220	11220	182838
Worked Material			5772	5694	4763	4584	4275	—	6000	4228	—	4228	29316	49.4	30000	5000	5000	5000	5000	5000	5000	59316
% of Total Labor: 65	Expense Allocation		15239	12539	15179	12335	9303	—	10757	13704	—	13704	78299	51.4	74005	17420	13865	10875	10615	10615	10615	152304
10	Health Physics		1764	1924	1878	1861	1404	—	1158	1704	—	1704	10635	49.5	11385	2680	2133	1673	1633	1633	1633	21920
5	3340		1130	1058	1275	625	413	—	828	448	—	448	4949	46.5	5695	1340	1067	837	817	817	817	10644
4	3370-1		869	821	1149	1068	812	—	662	1094	—	1094	5813	56.1	4553	1072	853	669	653	653	653	10366
			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Contingencies			—	—	—	—	—	—	—	—	—	—	—	—	6110	1018	1018	1018	1018	1018	1020	
TOTAL			62519	58209	64366	61996	42904	—	46405	50533	—	—	—	—	357848	71480	90486	48022	47286	47286	47288	692375
Credits			—	—	574	7408	4393	12375	—	—	—	—	—	—	—	—	—	—	—	—	—	12375
Net Expenditures			62519	58209	63792	54588	38511	—	—	50533	—	—	—	—	—	71480	90486	48022	47286	47286	47288	680000
Cumulative Expenditures			62519	120728	184520	239108	277619	—	—	328152	—	—	—	—	—	399632	490118	538140	585426	632712	680000	—
Cumulative % of Total Budget			9.2	17.8	27.1	35.2	40.8	—	—	48.3	—	—	—	—	51.7	58.8	72.1	79.1	86.1	93.0	100.0	—
Unexpended Budget			617481	559272	495480	440892	402381	—	—	351848	—	—	—	—	—	280368	189882	141860	94574	47288	—	—

*Some of these symbols have been changed since this form was devised. See "ORNL Standard Practice Procedures Manual".

4.3 Communications

4.3.1 Dissemination of Information Within the Pilot Plant Section

One of the most difficult problems in the administration of any large group is the problem of transmitting information. This phase of organization requires as much or more thought and work than any other phase. Numerous methods of communication have been tried in the pilot plant, and even though these methods were thought to be foolproof, Problem Leaders and Operations Supervisors have been awakened at night to answer the telephone and affirm, reiterate, or pass on new instructions to shift personnel.

Generally, three types of information are passed on:

1. Broad information concerning the section.
2. Broad information concerning the program.
3. Specific information concerning details of the program.

These types of information are conveyed orally or in writing. The information may be either public (everyone can know) or private (only one or a few persons can know).

It is evident that several methods of conveying information are required. Some of the methods used in the pilot plant have been:

1. Semiannual meetings of the Section Chief with all members of the section. In these meetings, the future programs of the Division and of the Section were discussed.
2. Monthly and weekly meetings of the Problem Leader with all technical members of his group. In these meetings, the status of the program was reviewed, and future plans were discussed. It also furnished an opportunity for group discussion of the entire program.
3. Daily meetings of the Problem Leader with the technical members of his group and other members from the section, or other sections. In these meetings each person is given an opportunity to discuss his particular problem, and the entire group can discuss immediate problems freely.
4. Details of operation are conveyed by written instructions in a log book, by run sheets, and by special forms.

4.3.2 Dissemination of Information to the Operating Group

4.3.21 Monthly Shift Supervisors Meetings

Each month, the Problem Leader should meet with the Shift Supervisors in a group meeting. The Problem Leader should review the pilot plant program---its objectives, status, and accomplishments or failures. Each Group Leader, Chief of Operations, Chief Engineer, Construction and Maintenance Engineer, etc., should discuss the status of his work and the future work of the group. This meeting also gives the shift supervisors an opportunity to discuss their problems between themselves and with the Group Leaders. This type of meeting results in improved morale of the Shift Supervisors (they feel that they are part of the technical staff and not merely operators), greater unification of the whole group, and, often, valuable suggestions from the Shift Supervisors that improve processing efficiency.

These meetings require careful planning. An agenda should be prepared, and the Group Leaders should be notifed sufficiently in advance that they can prepare an informative, well-organized talk.

4.3.22 Weekly Shift Supervisors Meetings

The outline for a weekly meeting is similar to the monthly meeting except that the scope of the subjects is narrower and the meetings are usually held only during processing periods. Weekly meetings usually are not held during shutdowns for equipment revisions.

The main topic at a weekly meeting is usually the process run about to be made. The run conditions (flow rates, concentrations, pulse characteristics, etc.) are given, and the run profile (startup, equilibrium operation, and manner of column shutdown) is described. All other pertinent information, as well as side-light information, is given to the Shift Supervisors.

The chief objective of weekly meetings is to present all the information concerning the run to the Shift Supervisors so that they will be prepared to make intelligent decisions and exercise judgment during the run consistent with the objectives of the run.

4.3.23 Daily Meetings

The Problem Leader should meet each day with technical members of his group as well as interested persons from the Division who wish to come to the meeting (design engineers, chemists, unit operations engineers). These meetings should begin promptly at a specified time each day and usually last 20 to 30 minutes. The Problem Leader should allow everyone attending to briefly discuss his work, presenting an up-to-the-minute status.

4.3.24 Run Sheets

An exact, step-by-step procedure for making a process run from startup to shutdown and all the data sheets required for recording the desired chemical and equipment process data are given to the operating group in a run folder. The run folder also contains the run conditions, sampling schedule, and waste disposal information, as well as all other information required to conduct the run properly. For example, the run folder for the Thorex Pilot Plant run contains 15 individual folders, which have a total of about 112 pages of typed, multilithed information.

These run sheets are usually prepared by one person, usually Assistant Chief of Operations, who coordinates the requirements of all the operational groups---data, engineering, chemist, etc. Often, if a change is made in the run, the run sheets will have to be changed in four or five widely separated places. This requires that the person preparing the run sheets practically memorize them as well as the equipment flowsheet. He also is responsible for keeping the run sheets up to date, and in order to do this, he must have a detailed knowledge of equipment revisions or additions. This person usually has to determine the exact procedural details for operating newly installed equipment.

After the run folder has been prepared, it should be checked and approved by the leaders of the pilot plant groups before it is given to the shift personnel.

4.3.25 Program Log

The program log is a bound notebook in which the Chief of Operations transmits daily instructions or information to the shift personnel. The entries are usually made about 3:30 p.m. and usually concern the next 24 hours of operation. On Friday afternoon, the program for the weekend is written.

4.3.26 Shift Log

The shift log is a bound notebook in which shift personnel write a log of the events on each shift to inform succeeding shifts the status of operation.

4.3.27 Standard Procedures Book

The standard procedures notebook is a loose-leaf notebook which contains procedures for doing standard operations, such as operating the sampling equipment, transferring wastes to the tank farm, and operating the off-gas ventilation equipment in the stack area.

4.3.28 Letters

Occasionally, it is necessary to transmit some instructions or information to the operating group and be sure that everyone on shift has read the information. This is usually handled by writing a letter to the operating group and typing the initials of all shift personnel on the letter. After the operating personnel read the letter, they initial it to indicate that they have read and understood the letter.

4.3.29 Conversation

All day-shift technical personnel are on 24-hour call during a process run to assist the Shift Supervisor if necessary. Most of these calls are made by telephone; however, to personally contact the 12-8 shift personnel, the group leader may come to work earlier than 8 a.m.

Even though the telephone is such a common-place instrument, it is a very important communications link for the Shift Supervisor. For instance, the Shift Supervisor rarely is given authority to dispose of marginal quantities of valuable materials in a waste solution; the approval must come from a higher supervisory level. Therefore, the Problem Leader must establish authorization procedures and should ensure that one or more persons are always available on call, including holidays and weekends, during a process run.

4.3.3 Recommendations

Many individuals in a pilot plant make valuable recommendations for which they do not have the prime responsibility. In general, these recommendations should be discussed with all interested parties, and then submitted to the individual who does have prime responsibility for the matter. The originator can make the recommendation either verbally or in writing, at his discretion. If made in writing, the Chief of the Pilot Plant Section and the Problem Leader should receive a copy. Written recommendations can be quite informal, but should be reasonably well thought out.

A person who receives a recommendation should discuss it with the originator within a reasonable time, and should advise him of the action, if any, to be taken on the recommendation. If no action is taken, the reasons therefore should be stated. This can be done either verbally or in writing, at the discretion of the person receiving the recommendation.

If after a reasonable time the originator feels that his recommendation is not receiving proper consideration, he should make the recommendation directly to the Section Chief, either verbally or in writing, and, if it is written, the Section

Chief will reply in writing within a week, if at all possible.

4.3.4 Reports

The value of the materials that a radiochemical separations pilot plant produces cannot be discounted, and the information transmitted to the Commission pertaining to the over-all results of a program are important, but it is more important that the technical information and the know-how from a pilot plant be recorded and transmitted to design and research people so that the amount of guesswork for the design of new plants may be reduced to a minimum. Reports must be written on every phase of operations because a production plant will be concerned with the same phases only on a larger scale. Plant construction and operation schedules may also be geared to some pilot plant operation. Pilot plant reports must be timely, factual, and accurate to achieve their maximum value to others.

There are two general types of reports: progress reports and final reports. Run summaries, equipment reports, radiation reports, status reports, in fact, any report that is issued periodically and contains timely information, can be classed as a progress report. A progress report is sometimes called a private or privileged report. A final report is sometimes called a terminal, a closeout, or a public report.

The progress report presents a changing, uncompleted picture of the progress (or lack of progress) being made to bring a problem to completion. The final report does not report progress---it reports success or failure.

Both progress and final reports may contain middle-ground information; that is, a progress report may contain final, definitive information, and a final report may contain interesting and useful, but unconfirmed, information.

When writing a progress report, the writer has certain privileges not enjoyed when writing a final report. A progress report may be written in a rather informal (but still quite professional) style, but a final report must be written in cold, exacting language.

4.3.41 Progress Reports

a. Functions. The progress report is written for two broad reasons: (1) to convey information, and (2) to provide a record of information recently obtained. There are several functions of a progress report, probably the most important one being to inform Management of the progress being made on a research problem, the problems being encountered, and what is to be expected in future work. The progress report either reassures Management that the investigation is proceeding wisely, or it may reveal that the work should go in a new direction, requires additional help, or needs technical guidance.

Progress reports help to convey new information to other research groups in the organization. This helps to avoid overlapping of work. Also, these reports are helpful when it is necessary to adjust the research schedules of several coordinated groups. When work is sponsored or paid for by organizations other than the writer's, periodic reports are required to keep the customer informed of the progress and to foster a good client-consultant relationship.

Writing a progress report that meets high professional standards benefits the writer: it causes the writer to organize his work, to think logically and clearly, ~~and to evaluate his accomplishments.~~ It is much easier to write a final report when several progress reports have been written, because ~~the~~ information was sorted, analyzed, and evaluated when new. In addition, progress reports keep the writer's name in front of Management, and after several reports, the name is fixed indelibly with an impression of the writer.

b. Distribution. The writer of a progress report usually makes up the distribution list of persons who he believes will be interested in receiving a copy of the report. The writer usually has no control over the distribution list for a final report.

c. Scope. The definition and functions of a progress report form a background for determining the scope of the report. Essentially, the scope should include all the available information that is necessary to fulfill the functions of the report. It should include data; a description, exposition, and evaluation of the data (including facts and intelligent opinions, each clearly defined); problems encountered and how they are to be solved; and the future program of the investigation. Of course, the report should not be slanted in a manner that would be detrimental to the writer's employer, nor should preliminary data be emphasized. This is legitimate, because it is reasonable to assume that temporary setbacks will be resolved with continued investigation.

An important point for the writer to remember is that the report should not contain sensational information until the information is substantiated, nor should the report be written in a sensational manner. Usually this type of information or style of writing has to be watered down in subsequent reports.

d. Statement of the problem and background. In an initial progress report, a complete statement of the problem and the background of the problem should be given. The importance of this investigation should also be related to allied investigations (if others are being conducted). If the investigation is of limited importance, it should be stated. (Radiation reports are more important to the Pilot Plant Section, usually, than to other groups.) In subsequent reports, a much more concise statement of the problem may be written, but clarity should not be sacrificed. There should not be any doubt in the reader's mind of the exact nature of the problem.

e. Description of the work. The writer should state what was accomplished during the report period. He should include data and observations, and these should be presented lucidly, using curves, simple tables, drawings, and photographs.

Some writers wonder if test or run conditions should be reported from month to month when the conditions have not been changed (for example, column dimensions, pulse stroke, frequency). The answer is yes for two reasons: (1) the reader does not have to refer to previous reports to refresh his memory (he certainly cannot remember these things), and (2) it is much easier to write the terminal report when all data are recorded for consecutive periods.

f. Evaluation of the work. The work should be evaluated in reference to the immediate significance of the work and to the long-range significance to the overall problem. Statements of fact should be substantiated by incontrovertible evidence, and statements of judgement should be explained, giving the reasoning used and the facts employed. It may be necessary to refer the reader to experimental data presented in previous progress reports (complete reference required) or it may be desirable to review and consolidate previous data for presentation in the current report. The writer should judge for himself the requirement in each case, remembering that the report is written for the reader and not the writer.

g. Program schedule. Each progress report should contain a program schedule, and progress (or lack of progress) for a report period should be reported in terms of the schedule.

The report should indicate whether or not the schedule is being met and the period of time ahead or behind schedule. The reasons for the program status should also be given. Any difficulties that have upset the schedule should be explained. If it appears that current difficulties will upset the future schedule, an explanation should be given. If additional help is required to meet the schedule it should be stated. Also, the program for the next report period should be presented.

h. Decisions. The reader should be kept informed of any significant decisions that affect the over-all program. The decisions should be reported clearly and completely with all the attendant facts and reasoning behind the decision.

4.3.42 Final Reports

Final, or terminal, reports are written after a program has been completed. Usually (unless restricted because of security reasons) final reports are published as formal ORNL reports and are given wide distribution in the Atomic Energy Commission. Because of this, the standards imposed upon the writer are higher than for CF memos. The language must be exact, and the makeup of the report must be highly acceptable. A final draft of the report must be edited by the Chemical Technology Division Reports Editor and approved by the Division Director before the report can be published. There are two guides for an author to follow in writing a final report[16, 17] and several examples to follow.[18-23]

Before writing a terminal report, the author should prepare a detailed outline of the proposed report and submit it to the Pilot Plant Section Chief for approval. This will save the writer considerable time by not having to change the organization of the report after the first draft is written. After the draft is prepared, the report must be reviewed by the reviewer for the Pilot Plant Section and approved by the Section Chief before it is submitted to the Division Director for approval and publication.

4.3.43 Run Summaries

A run summary is a report issued after a processing run is completed in the pilot plant. The report contains a complete tabulation of all the data from the run, as well as a complete evaluation of the run and a comparison with other experimental data. The reports should be issued as soon as possible after run completion. In major pilot plant programs, such as Purex and Thorex, the goal of the data group is to issue the run summary within three weeks after run completion.

During the Purex program, the organization and style of the run summary was developed, and Thorex run summaries were set up almost identical to the Purex summaries.[24, 25] During the Thorex program, a routine procedure for writing and publishing the run summaries was developed. The procedure is:

a. Assemble the data from analytical reports, log books, run sheets, check sheets, and instrument charts.
b. Evaluate the data, and request additional data if necessary.
c. Organize the outline of the report such that the report will represent the true results of the run.
d. Organize the data and discussions into a rough draft.
e. Evaluate the entire body of data and discussions.
f. Polish the written part of the report.
g. Prepare an index of figures, tables, flowsheets, flow diagrams, etc.
h. Prepare an introduction and summary.
i. Circulate the summary section of the report among other personnel to pick up errors, discrepancies, deletions, etc.
j. Polish the entire report, correcting errors, deletions, etc.
k. Have the report edited and make editorial corrections. Resubmit the report for editorial approval.

l. Type the approved draft on mats, proofread, and submit the report for final approval.
m. Have the report reproduced and distributed.

The outline of the report changes very little from run to run; it is changed only in the subsections of the report when some phase of the process has been studied more or less closely than previous runs.

4.3.44 Weekly Radiation Exposure Reports

Each pilot plant handling radioactive materials should write a weekly radiation exposure report. Any report, including this type, has two broad functions: to convey timely information to the reader, and to serve as a record of data, observations, and conclusions for further reference. The first function can best be served by getting weekly reports written and distributed quickly---within one week following the report week. The second function will best be served by setting up a skeleton outline of the weekly report with form sentences (leave blank spaces for numbers), tables and figures, and leaving sufficient space for additional comments. With this system, less than a day's work will usually be required to write the report.

a. Objectives:
    1. To be used as a tool for analyzing operations.
        (a) Determine sources of radiation and necessity of additional shielding, restricting areas, or more strict personnel radiation control.
        (b) Determine the relation between unexpected operational upsets and personnel exposures and building radiation levels.
        (c) Determine which persons chronically receive excessive exposures and overexposures.
    2. To be used as a tool for planning operations.
        (a) After analysis of operations is completed, the conclusions may indicate the necessity for some immediate action regarding the equipment or personnel, or they may indicate satisfactory conditions and no need for immediate action.
        (b) After several weeks of analysis, future action may be required which may affect the budget, manpower, maintenance requirements, etc.
b. List of data and information to be included:
    1. Data
        (a) Table showing how much exposure was received, where received, and how (by areas and jobs).
        (b) Figure showing total exposure, average exposure, number of overexposures.
        (c) Table showing individual exposure data.
        (d) Table showing building surveys (note on the table which equipment is unit shielded and which is not).
        (e) Table showing the number of times a job was done or an area was entered, total exposure received, and the average exposure received per area or job.
    2. Information
        (a) Summary statement of whether the plant was running or shut down. If running, what was being processed. If shut down, why it was shut down, and what work was being done.
        (b) Statements of conclusions based on the data analysis.
        (c) Statements of action to be taken, if any, and whether it is immediate or future.

4.3.45 Quarterly Radiation Exposure Reports

Weekly radiation exposure reports form the background for a quarterly report. The subject of radiation exposures in processing plants over extended periods is an important and sensitive subject, and for this reason, reporting of exposure data requires factual and penetrating analysis, and logical conclusions. The report must present unified thought of the Pilot Plant Section, and should represent the best interests of the Chemical Technology Division and Oak Ridge National Laboratory.

The readers of this report will be competent engineers and physicists---the report must be equally professional.

a. Objectives:
   1. To give design and operating engineers an over-all picture of radiation exposures, radiation levels, and air and surface contamination in a directly maintained radiochemical processing plant.
   2. To tell where, how, and why exposures occurred.
   3. To present a correlation of the exposures with the design and routine operation of the plant.
   4. To describe unusual operational events and their effects on the plant radiation picture.
   5. To tell of equipment, shielding, or operational changes that were made because of radiation considerations.

b. List of data and information to be included. The format for this report should conform to the standard formal report, i. e., Contents, Abstract, Introduction, Summary, Body, Bibliography (references), and Appendix.
   1. Data
      (a) Complete routine exposure data on all operating and maintenance personnel and, if available, other personnel, such as analytical. These data include: total exposure, average exposure, and number of overexposures.
      (b) A breakdown of the exposure data into locations and jobs.
      (c) Special exposure studies, such as decontamination, maintenance, or some operation done under strict supervision and close radiation control.
      (d) Plant radiation surveys, by locations or functions of equipment or both.
      (e) Air surveys.
      (f) Contamination (smear) surveys.
      (g) A list of radioactive area equipment failures and the radiation exposure resulting from each failure.
      (h) Special shielding studies.
   2. Information
      (a) What the plant was processing, the radiation levels, decay period, etc.
      (b) What was done during downtime, if the plant was shut down.
      (c) Correlation of all the data with plant operations and radiation measurements (surveys and exposures).
      (d) Conclusions based on analysis of data.
      (e) What action was taken to control personnel exposures, etc., during the quarter and the results.
      (f) What further action is necessary.
      (g) Long-range planning, if such is contemplated.
      (h) A few meaty, significant recommendations, based on the data, to design engineers to improve plant design.
      (i) Discussion of measurement techniques (e. g., comment on film badge and dosimeter readings).

4.3.46 Pilot Plant Cost Reports

Budgeting, estimating monthly costs, and analyzing monthly expenditures give the Problem Leader an intimate knowledge of the costs for his problem. These are important duties of the Problem Leader, but in order for benefits to be realized from these paper studies, this knowledge must be reported to all members of the group, for they are the persons who spend the money. No amount of studies of past expenditures can equal the effectiveness of controlling costs at the time the expenditures occur. Cost can be controlled only if all members of the group have a knowledge of purchase prices, labor rates, and various overhead charges.

In addition to the interest of the immediate group in knowing costs, others outside the pilot plant---Management, design engineers, chemists, and equipment development engineers---and outside the Laboratory---the AEC production site personnel and industrial managers---have more than a passing interest in knowing the pilot plant operating costs. A well-written, informative cost report is as important to public relations as a process development report.

Many types of cost reports have been published by the Pilot Plant Section. These are:

1. Costs of several consecutive problems
2. Cost of a single problem
3. Fiscal costs for a problem
4. Monthly operating costs
5. Construction costs
6. Analytical costs

The first of these reports, costs of several consecutive problems, is illustrated by ORNL CF-55-6-81. In this report, "Summary of the Metal Recovery Building Program Costs," seven programs in the Metal Recovery Building are described; the total cost for each program and unit recovery costs are presented; and the program costs are briefly analyzed.(26) This report presents the total capital and operating costs for each program, but does not detail the costs.

The second type of cost report, the cost for a single problem, is illustrated by ORNL CF-54-8-80, "Operating Cost for Recovering Uranium from Tank Farm Waste Solution."(27) This report gives the total operating cost and unit costs for recovering 101 tons of uranium and 208 grams of plutonium in a 13-month period. The cost is itemized by types of expenditures, and the costs of various process chemicals per pound of uranium are tabulated. Other reports of this type have been published by the Metal Recovery Plant.(18, 21)

A report titled "Purex Pilot Plant Cost Summary for F. Y. 1952" gives a detailed breakdown of labor, materials, and overhead costs.(28) This report illustrates the third type of cost report, i. e., a report of fiscal costs for a problem.

Monthly operating expenses have been reported in two types of reports. One type (29) gives a detailed breakdown of the labor, materials, and overhead costs. A second type (30) shows the monthly expenses for all Pilot Plant Section accounts. The Problem Leader's estimated expenses for a month are compared to the actual costs, and the rate of expenditure is compared to the scheduled rate for the fiscal year. In addition, the basis for the estimate and the program assumptions for each problem are listed.

During construction of the Thorex Pilot Plant, a construction cost report(31) was published each month. These reports were very brief, consisting usually of one table in which the monthly expenditures for several phases were itemized, and the accrued expenditures for each phase were compared to the percentage of job completion.

Several analytical cost reports have been published. One report presented a study of the cost of analytical services for the Purex Pilot Plant, describing several factors that influence analytical costs.(12) Another report presented the Chemical Technology Division costs for analytical services over a several-month period.(14 Other reports, issued monthly, described the Chemical Technology Division analytical costs and the number of Analytical Chemistry Division personnel supported by the Chemical Technology Division each month.(13)

4.3.5 Manuals

4.3.51 Operating Manuals

Prior to the operation of a pilot plant an operating manual should be written by technical members of the pilot plant operating group. This manual should contain a fairly complete summary of background information, that is, the chemistry of the process, the advantages of the process, and the use of the process. It should contain a section on operating procedures for special equipment and information, such as, specifications, toxicities, and instructions for handling process chemicals. An operating manual is valuable in two ways: in the training of new technical and operator personnel in the pilot plant and as a reference for the operating group.

In the Purex Pilot Plant an informal type of operating manual was written. As information was developed, it was typed and multilithed and these sections were put into a looseleaf notebook. Approximately 10 copies were prepared and were distributed among members of the Purex Pilot Plant group. Each notebook was classified secret rough draft. This type of binding made it easy to insert new information and to revise existing information. Administrative information in this manual, summarized from ORNL Standard Practice Procedures, included such information as hours of work, overtime policies, and vacation policies.

The operating manual for the Test Facility was prepared differently from the Purex manual.(32) The Test Facility manual was written and published as a bound document(33) and was given wide distribution not only to the Test Facility group but to others in the division working on the same problem. This manual contains chapters on the process chemistry, equipment descriptions, detailed equipment operating instructions, process materials data, and safety. The material for the Test Facility manual was contributed by pilot plant personnel, design engineers, and laboratory chemists and was edited by one pilot plant person. There are two conclusions drawn from the preparation of this manual: First, the inclusion of detailed operating procedures for all the equipment proved to be worthless to the operating group because the procedures were obsolete very soon after the equipment was started in operation. After the equipment was put in operation, a number of minor piping changes were made and valves were both installed and removed over a period of several months. It was virtually impossible to continue revising the operating instructions as these changes were made and, because the document was bound, it could not be changed easily to take the newer information. Secondly, a description of the equipment was incorporated in the manual. This would have been better put into a separate equipment manual. It would be better if the operating manual contained only information that probably will be true for a long period of time, other less permanent information being put into a separate type of manual which can be changed easily.

The preparation or writing of an operating manual is a tedious and exacting job and for this reason the selection of the writer or editor requires considerable thought. The writing of an average operating manual containing 200 to 500 pages takes easily over two months of full-time work. The writer must have a fair background in the process before he begins to write, and, as he writes, he will require more detailed knowledge of the process.

If an editor is selected to combine the writings of several contributors to the manual, he must be a congenial type of person and must have the ability to persuade others that their contributions will be of value. He must also have the ability to persuade the contributors to submit the material by deadline dates. The writer of an operating manual should have had considerable writing experience and should be recognized as a good report writer. A new employee without previous reporting experience or an older employee who is a poor writer would find the job of preparing the operating manual an extremely frustrating experience.

The process chemistry section of an operating manual should contain not only a description of the flowsheet but should contain basic laboratory data and information. For example, it should contain sections on stage heights, distribution coefficients, decontamination factors, throughput data, and other basic studies that were made on a laboratory scale. This type of information often is very helpful to the shift supervisor in trouble-shooting column misoperation. Wherever possible figures and tables relating to fundamental data should be inserted in the process chemistry section.

An operating manual should also contain a bibliography of reading material related to the process. This information is helpful in training new technical persons who wish to get a wider background on the process than is presented in the operating manual.

4.3.52 Equipment Manuals

The equipment manual in the pilot plant supplements the operating manual. It should contain a list of all the equipment in the pilot plant, a description of the equipment, its operating data and dimensions, piping, etc. The manual should contain numerous simplified sketches of the equipment. It should also contain instrument lists and piping lists as well as instructions for operating special equipment, special maintenance procedures, and special lubrication procedures.

The equipment manual serves as a reference book for the shift supervisor. Many times in a period of operational difficulty the shift supervisor must look up some reference to obtain information, and most often the reference is a detailed drawing of the piece of equipment. Engineering drawings are not handy references because it usually takes the shift supervisor too long to determine some dimension or location of a piece of equipment; schematic drawings with dimensions are much better. It is usually a difficult job to train an operator to read engineering drawings. A well-prepared equipment manual is a valuable training aid for operating personnel.

An equipment manual should not contain all the vendor's information that has been received on the pilot plant equipment. It is much better to file vendors' information in a separate file, but for specialized equipment, for example, a centrifuge, some of the vendors' information may be incorporated in the equipment manual. In the case of the centrifuge, special operating instructions could well be included in the manual, as well as lubrication instructions and the more frequently needed maintenance instructions.

The preparation,format, and type of binding for an equipment manual are very similar to those of the operating manual, and each problem leader should decide for himself which type of document should be prepared.

4.3.6 The Preparation and Review of Pilot Plant Reports

One person in the Pilot Plant Section acts for the Section Chief in the capacity of critic and reviewer of all reports written for distribution outside the Pilot Plant Section. The objectives of his work are:

1. To assist in making reports adequate in quantity and outstanding in quality.
2. To assist each member of the section in increasing his proficiency as a report writer.

In addition to reviewing reports in their final form, the reviewer is available during the preliminary stages of report preparation to discuss such items as objectives, organization, style, scope, title, and distribution.

After preliminary discussions of the report, if any, have been completed, the report writer should assume responsibility for preparation of the best possible draft to submit for formal review. After ensuring that technical matters have been treated in proper detail, accuracy, and perspective, the report writer should give attention to improving sentence structure, vocabulary, and general format of the report. The report should be rewritten until the writer feels that he has done his best. The final draft should be typed and carefully proofread before submission for review. Over a period of time the report writer's ability to prepare reports will be judged largely by the quality of this draft.

The review should be concerned primarily with the technical content of the report and not with grammar, spelling, or punctuation. The reviewer will also criticize the general composition of the report and will make sure that the report represents the best interests of the Pilot Plant Section and the Division.

After the reviewer has approved the report, the Section Chief reads the report for final approval.

4.4 Health Physics Services and Radiation Control

A complete radiation control program, established in the Purex Pilot Plant, and attendant Health Physics services are described in a published report.[34] Other pilot plant reports describe radiation and exposure conditions during Purex Pilot Plant operations.[35, 36] Weekly and quarterly radiation exposure reports have been published by the Thorex Pilot Plant.[37]

4.5 Instrumentation

All pilot plant instruments should be serviced and repaired by Instrument Department personnel and not pilot plant personnel. The type of service required from the Instrument Department depends on the number and type of instruments installed in the pilot plant and the length of time the pilot plant has been in operation. Initially, and until the pilot plant is running smoothly, an instrument engineer is required full time, and, as the instrument troubles lessen, half or part time. After several months of operation, the instrument engineer may be called only when necessary.

The same tapering off of service is usually followed for instrument technicians. If the pilot plant contains a large number of instruments or several unusual or untried instruments, such as newly developed analytical instruments, an instrument technician may be assigned full time to each shift, working under the direction of the shift supervisor and instrument engineer. If full shift coverage is not necessary, an instrument technician may be assigned to the pilot plant on the day shift to repair, test, or install new instruments.

If only routine servicing or minor repairing is required, shift instrument technicians are on call 24 hours a day. These men work throughout the Laboratory, and will report to a pilot plant only when requested. Regularly recurring servicing, such as changing charts, filling pens with ink, or making minor adjustments, can be set up on a schedule with the foreman in charge of the shift group.

It is the responsibility of the instrument engineer to furnish shift instrument technicians with all information required to service the instruments, such as chart changing schedules, dating and inking instructions, and types of charts required. An instrument list, giving the specifications for each instrument, should be available in the pilot plant control room. The instrument engineer should keep the instrument list up to date as new instruments are installed or as instruments are modified. A central location for obtaining instrument charts should be provided in the pilot plant.

The instrument technician should record what he did in the pilot plant by writing in a pilot plant instrument log book. (In the Thorex Pilot Plant, instrument charts, small supplies, and the instrument log book are kept in a partitioned-off section of the operating area called the "instrument cage".) The instrument technician also writes a record of his activities in the shift instrument log book, which is kept in the foreman's office.

Services and techniques for instrument servicing and repair are easily set up, having been developed over a period of several years by both the Instrument Department and the Pilot Plant Section. One of the problems in operating a pilot plant is to set up techniques which ensure that the operating personnel make systematic and regular checks of instrument readings to determine that they are within operating limits, to spot malfunctions of equipment, or a possible trend toward malfunctioning quickly before serious trouble develops, and to record the exact nature of the trouble and the remedial action taken. In the Purex Pilot Plant, the following techniques were developed:

1. Instrument check lists. The instrument engineer prepared three separate check lists (Fig.4-13): a list for checking the instruments every 15 minutes, every hour, and every four hours. On each sheet several instruments were listed in one column, and in a second column the set-point for each instrument was shown. In two columns the operating limits were shown, one column listing good (or desired) operating limits and the second listing satisfactory limits. In a fifth column, remarks pertinent to the

Fig. 4-13a

Operations Sheet for Checking Instruments Every 15 Minutes

ORNL PILOT PLANT - PUREX PROCESS

Date________ Shift________ Run________ Checked by________

CHECK	SPECIFICATION OR SET POINT	OPERATING LIMITS		REMARKS
		GOOD	SATISFACTORY	
B-13 LL			2.2 - 4.0	If reading above 4", check Cell I off-gas vent manometer on roof
B-14 LL	2-3"	2-3"	2-4"	
IA controller Output air gauge Output air record	14.2	14.15-14.25 10-14 psig 10-14 psig	14.1 - 14.3 8-16 psig 8-16 psig	Interface will be 6" above bottom probe at 14.2
IAP SG (manometer)			11.6-11.7	
IAP SG (recorder)	58 (0.969) 91 g/liter	57-58 88-91 g/liter	56-59 85-91 g/liter	Check C clamp if out of specification
IBU SG	47 (0.939) 72-73 g/liter	46.5-47 72-73 g/liter	45.5-48.0 69-73 g/liter	Check C clamp if out of specification
B-7 SG (manometer)	9.45 #2 (1.60) 445 g/liter	9.40-9.50 (1.59-1.61)	9.40-9.50 (1.59-1.61)	5.9" probe separation
A-8 LL			No increase	Investigate source of any unexplained buildup
IB controller Output air gauge Output air record	13.3	13.25-13.35 7.5-10.5 psig 3.5-3.5 psig	13.3-13.4 6-12 psig 2-4 psig	Interface should be 7" above bottom probe at 13.3

Fig. 4-13b

Operations Sheet for Checking Instruments Every Hour

ORNL PILOT PLANT - PUREX PROCESS

Date________ Shift________ Run________ Checked by________

CHECK	SPECIFICATIONS OR SET POINT	OPERATING LIMITS		REMARKS
		GOOD	SATISFACTORY	
C clamps	0.5 cfh except where marked differently		0.5 cfh	B-25 control SG should be set at 0.1 cfh
Air to IIA and IIB pulsers	15 psig		14-16 psig	
Pulse frequencies	See run sheets			
Pulse pump stroke	A, 3" D, 3" B, 2-3/4" E, 4" C, 4" S1, 4"			Do not stop pump to check stroke unless absolutely necessary; check for leaks, overheating
Feed pumps				Check for overheating, leaks, knocking
C-26 LL	Decrease 0.231 in./hr			Check pump delivery
B-9 LL	Not less than 12" 1.55 at 105°C			Buildup rate should be 3.4 in./hr
E-21 LL	Not less than 30" 1.55 at 105°C			Buildup rate, above 30", should be 0.8 in./hr
D-30 LL	Not less than 7" 1.10 at 105°C			

Fig. 4-13c

Operations Sheet for Checking Instruments Every 4 Hours

ORNL PILOT PLANT - PUREX PROCESS

Date________ Shift________ Run________ Checked by________

CHECK	SPECIFICATION OR SET POINT	OPERATING LIMITS		REMARKS
		GOOD	SATISFACTORY	
IA controller Sensitivity Reset	 300 5			
Main process tank vent vacuum	3.6"		3-4"	
IB controller Sensitivity Reset	 300 5			
Cell I vacuum	0.5"			
Cell II vacuum	0.25"			
IC controller Sensitivity Reset	 50 5			
$\overline{B}$-25 sensitivity	15			
All temperature points				Check boildown tanks, condensers, etc.
Monitrons				Check monitron recordings
IIF filter head	0		0	Turn Cuno if head builds up
IA controller Sensitivity Reset	 300 5			
IIB controller Sensitivity Reset	 50 5			
ID controller Sensitivity Reset	 50 5			

instrument check were made; for example, if a vessel vent pressure was too low, the checker was instructed to check the main header pressure.

2. Engraved signs. Operating limits for instruments were also engraved on plastic squares and installed on the control panel. However, some check list is required to ensure the operators' making a systematic routine check of the instrument readings.
3. Instrument Failure Form. Whenever an instrument required correction or repair, the shift supervisor filled out an Instrument Failure Report form (Fig.4-14). The form was devised to obtain a more complete and accurate account of instrument operation and the number, kind, and frequency of instrument failures, in addition to determining that the necessary repairs or adjustments had been completed. The form provides space for recording the following data:
   - (a) A number used for indexing.
   - (b) The number and type of instrument.
   - (c) The trouble noted, such as low reading or poor control. This is not intended to be a diagnosis of the failure.
   - (d) The name of the person originating the report; the time and date.
   - (e) The cause of failure. This should be recorded by the instrument mechanic or the information should be obtained from him.
   - (f) Correction required. This should be recorded by the instrument mechanic or the information should be obtained from him.
   - (g) The name of the instrument mechanic making the repair; the time and date.
   - (h) Suggested changes in procedure or equipment to prevent recurrence of the trouble.

   The reports were collected and checked each day by the instrument engineer and the head of operations. The reports were filed and cross-indexed to determine recurring failures of the same instrument.
4. Routing of instrument charts. An instrument chart constitutes prime data from processing operations and should be regarded as such. In Purex operations, many times instrument charts would be taken from the control room by the engineering group or be held by the operating group, and the data group would receive only some of the charts. Often charts would not be returned to the data group, and would be found in desk drawers and files. To correct this situation, the instrument technician was instructed to place all instrument charts in a box and all charts were to be delivered to the data room. The data group was responsible for filing and storing all charts, and all other groups requested charts from the data group on a loan basis.

Fig. 4-14

Instrument Failure Report Form

The principal reason for this form is to obtain a more complete and accurate account of instrument operation and the number, kind, and frequency of instrument failures. In addition it will provide a means of determining that the necessary repairs or adjustments have been completed.

Description of the Form. The form provides space for recording the following data:

1. A number which will be used for indexing.
2. The number and type of the instrument, e.g., B-40 LL and SG.
3. The malfunction such as low reading or poor control. This is not intended to be a diagnosis of the cause of failure.
4. The name of the person originating the report; the time and date.
5. Cause of failure. This should be noted by the instrument mechanic or the information should be obtained from him.
6. Correction required. This should be noted by the instrument mechanic or the information should be obtained from him.
7. The name of the instrument mechanic making the repairs; the time and date.
8. Suggested changes in procedure or equipment to prevent recurrence of trouble.

All these data should be noted as completely but as briefly as possible. The reports are collected and checked each day. A file is kept to provide a cross index to recurring failures on the same instrument.

INSTRUMENT: ____________________

TROUBLE: ____________________

____

____

____

____

REPORTED BY: ____________ TIME: ________ DATE: ________

CAUSE OF FAILURE: ____________________

____

____

CORRECTION REQUIRED: ____________________

____

____

____

CORRECTED BY: ____________ TIME: ________ DATE: ________

PROCEDURE OR EQUIPMENT CHANGE SUGGESTED: ____________________

____

____

____

____

____

____

4.6 Maintenance Services

Procedures for submitting blanket, regular, and emergency work order requests for approval are given in the ORNL Standard Practice Procedures Manual. These procedures are straightforward; the required paper work is simple and takes very little time.

Aside from major construction programs (Section 2.3.3), a pilot plant requires three types of maintenance service:

1. Nonscheduled minor maintenance or repair (called "shift maintenance"), necessitated by minor equipment failure which usually requires less than 8 hours.
2. Scheduled routine construction and maintenance done by day-shift personnel. These jobs usually take more than a week.
3. Scheduled high-priority construction and maintenance. This type of work is usually too big a job for shift maintenance personnel to accomplish by themselves and requires day-shift craft supervision and manpower.

A request for minor maintenance on shift is handled by personal conversation between the pilot plant shift supervisor and the shift maintenance foreman. A blanket work order is written for each job. The other two types of maintenance, routine and high priority, require a systematic procedure for transmitting requests to the Mechanical Department. The Purex Pilot Plant established the following two procedures for transmitting information, and they were very satisfactory over a long period of time.

4.6.1 Procedure for Routine Construction and Maintenance

1. At 1:00 p.m. each Wednesday, the Chief Pilot Plant Engineer will furnish the Mechanical Department, Area Engineer, with the necessary job lists, sketches, and drawings for the work which the pilot plant feels should be accomplished during the following week. Two copies of job lists and one print of sketches or drawings will be furnished.
2. At about 1:15 p.m., these two engineers will go to the Area Maintenance Office and discuss the proposed work with the Area Craft Foremen. All personnel in the pilot plant concerned with maintenance and construction will be available to furnish any required information. The pilot plant engineer will be informed whether the information furnished is adequate for the jobs requested, and will be informed if additional work orders are required. Any additional information required from the pilot plant will be furnished by 4:00 p.m., Wednesday. An estimate of the manpower required to do the work will be made, and this estimate will include an allowance for some unforeseen changes which are required each week.
3. One pipefitter will be available full time for routine maintenance as directed by pilot plant personnel (not Mechanical Department supervision).
4. The Area Engineer will transmit the information developed in these meetings to the Senior Area Supervisor, and the Pilot Plant Engineer will transmit the information to the Pilot Plant Section Chief.
5. By noon Friday, the Area Engineer will tell the Section Chief how much of the requested work can be done during the following week, and what manpower will be assigned.

4.6.2 Procedure for High-Priority Construction and Maintenance

The following procedure will be used for high-priority changes or additions which become necessary during the week.

1. The Area Engineer will be notified of the change immediately. He will be given the following information:
   a. Description of the necessary change or addition.
   b. The priority which the pilot plant assigns to the job.
   c. The pilot plant estimate of the manpower required to do the job.

   At this time, the Area Engineer will decide whether a new work order is required.
2. Details (job list, sketches, etc.) will be transmitted to the Area Engineer at the earliest possible time. Pilot plant personnel and the Area Engineer will discuss these details with the crafts involved to determine if the information is adequate.
3. The Area Engineer will inform the Senior Area Engineer of the changes or additions if the required manpower is more than the manpower allotted for changes during the week. If more manpower than was originally scheduled is required to do both the changes and the regularly scheduled work, the Area Engineer will inform the Section Chief whether or not this additional manpower will be available.
4. There will be some occasions of an emergency or extremely high priority nature when immediate service is required. On these occasions pilot plant personnel will go directly to the proper craft foreman if the Area Engineer is not immediately available to get the job done. The Area Engineer will be advised of the action taken.

4.7 Overtime

It is the policy of the Pilot Plant Section to keep the number of overtime hours to a minimum consistent with efficient operations. However, when overtime is necessary, the opportunity for overtime shall be kept as equally as practicable among the operators. Overtime will be assigned only when it is reasonably certain that there is sufficient and urgent work necessary to be done on overtime. Because the process operations are semicontinuous, it is not necessary that a standard crew of operators be present at all times; therefore, overtime will not be granted simply because an operator failed to report for work.

Shift supervisors should obtain an authorization to hold a man over for overtime from the chief of operations or from the problem leader. If it is known 4 or more hours before a shift changeover that overtime will be necessary, the shift supervisor on duty should request overtime. If it is not known until shift changeover that overtime is necessary, the shift supervisor on whose shift the overtime will occur should request overtime.

A weekly overtime list is issued each week and is posted on bulletin boards for all interested parties to check.

An operator must work in the Pilot Plant Section 12 weeks before he is eligible for overtime. All operators in the Pilot Plant Section are eligible for overtime after the 3 months' probationary period.

Overtime will be offered to the lowest man on the overtime list, including those on a long weekend, provided the man is familiar with the particular plant where the overtime is required. It is the policy to use men regularly assigned to a specific plant for necessary overtime in that plant unless the work is such routine nature that any experienced operator can handle the work.

Men who are offered overtime and turn it down will be charged for that overtime on the overtime list unless: (a) The man involved is ill or there is serious illness in his family, (b) the man involved is on a long weekend, (c) the man is leaving on vacation.

4.8 Protective Clothing

Protective clothing is furnished an employee by the Laboratory where there is a likelihood that the employee's clothing may be contaminated. All persons working in a pilot plant such as Thorex are furnished clothing. These persons include pilot plant personnel, maintenance personnel, and visitors. The clothing issued includes coveralls, caps, gloves, socks, shoes, lab coats, and shoe covers. The pilot plant keeps a stock of clothing in the locker room, and each person withdraws clothing as required. Contaminated clothing is placed in bags and is picked up by laundry employees, and after the clothing is washed, it is returned to the pilot plant.

Two items of protective clothing, coveralls and gloves, require more attention than any other. The most popular and serviceable coverall is cotton, although in recent months coveralls made from synthetic fibers have been used. The synthetic garments are more expensive, costing three times as much as cotton, but their life is much longer.(38) Synthetic garments can withstand many more washings and show less shrinkage than cotton.(39)

Neoprene-coated gloves are usually worn by operation and maintenance personnel in contaminated areas. Unless these persons are periodically reminded to try to utilize the gloves as long as possible, the number of gloves purchased for a pilot plant becomes unreasonable. Many times these persons will obtain a new pair of gloves for each task, regardless of the condition of the glove. Since these gloves cost about $0.50 a pair, and it is virtually impossible to get these persons to wear washed used gloves, the Problem Leader should watch the purchase of gloves to keep the expenditure at a reasonable level.

4.9 Service Samples

Frequently, the operating group is requested to obtain process solution samples for other groups. The volume of sample requested may vary from 1 ml to 10-20 liters, and the solution may be anything from feed to recovered solvent. During Purex Pilot Plant operation, approximately fifteen special samples were taken during each run. A significant portion of pilot plant operations labor was devoted to obtaining sample bottles, shielded containers, and sampling over extended periods of time to prevent overexposures and disturbance of column equilibrium conditions.

In order that the pilot plant could best serve the Division research personnel, the following procedure for obtaining samples was established:

1. All requests for samples were made by an informal note to the chief of operations and a copy was sent to the process chemist.
2. Requests for chemical information concerning the samples were made to the process chemist.
3. When requests were made at least a week in advance, the pilot plant attempted to provide shielded containers for the samples. When less than a week's notice was given, it was sometimes necessary that the requester furnish the container.
4. Pilot plant sample containers were to be returned promptly so that they could again be made available for other samples.
5. Because of a lack of facilities for returning radioactive samples to the process, the pilot plant would not take back unused samples.

4.10 Training

4.10.1 Operator Training

Operating personnel should be given sufficient knowledge of their duties so that they can do a satisfactory job. They should also be given knowledge of their tools and materials so that they can use them intelligently. The training should be simple and brief, preferably on a high school level, and as much demonstration material as possible should be used. Three training techniques have been used in the Pilot Plant Section: (1) formal group training, (2) informal shift training, and (3) private counseling.

The first technique, formal group training, was conducted on the day shift for a period of two to three weeks prior to shift operation. In the morning, the operators assembled in a meeting room, and talks covering process chemistry and the chemical flowsheet, process equipment and the equipment flowsheet, instrumentation, sampling, operating procedures, safety, radiation, etc. were presented by technical personnel having an extensive knowledge of their subject. The operators took notes and were given tests on the talks. In the afternoon the operators were assigned to plant areas or to equipment units to study in detail the piping, construction, instrumentation, and operation of the actual equipment. The operators also were required to make sketches of the flowsheet and equipment arrangement, as well as of working parts of pumps, filters, valves, etc. At the conclusion of the training period, the operators were tested and, in some programs, their notebooks were turned in for review. This is a satisfactory type of training in that the operator is introduced to the process quickly and with considerable detail. However, much of the information is soon forgotten, particularly background information. Of course, the working knowledge increases with experience.

The second phase of training was conducted on shifts by shift supervisors. A series of training lessons was prepared by the chief of operations, and these lessons were distributed to the shift supervisors ahead of time so that they could prepare themselves to present the lesson to the operators. Each shift received a minimum of one 15 to 30 minute lesson per week, which was given during a slack period on the shift. The subjects were varied from general chemistry of the process to the detailed operation of a specific piece of equipment. At the conclusion of each lesson, the shift supervisor wrote an evaluation of the lesson for the operations leader, who modified the lessons to improve their value or acceptance.

A third technique of operator training is private counseling, based on operator evaluation by supervisors. At about twelve-month intervals, all supervisory personnel evaluate the operators in their group. The operations leader and assistant evaluate all operators in the group, while the shift supervisors evaluate the operators on their shift. The evaluation is done in a formal manner; each evaluator is given a set of instructions (Fig. 4-15) and printed forms for each operator to be evaluated (Figs. 4-16, 17, and 18). After all operators have been evaluated, the Problem Leader makes a composite of all operator ratings on a single sheet and places the operators' initials over each mark. A sheet is prepared for each operator, showing all ratings on the sheet but the initials of only one operator. In this manner, each operator can be shown how he compares to all others in the group. The operator progress form and rater comment form is also combined. With these forms as a basis for discussion, the Problem Leader can counsel each operator, pointing out his strong points as well as his weaknesses, and offer constructive advice for improvement. This technique has been well-received by the operators in several programs and has been very beneficial in improving the work habits and traits of many operators.

Fig. 4-15

Instructions for Filling Out

Operator Evaluation Forms

Three forms are to be completed by the rater; they are titled: Operator Evaluation Form (Fig. 4-16), Operator Progress Form (Fig. 4-17), and Rater Comment Form (Fig. 4-18). The Operator Evaluation Form lists 11 specific qualities on which each operator should be evaluated. On the Operator Progress Form the rater lists the name of each individual whom he has rated and indicates whether the individual has or has not made progress. The Rater Comment Form is supplied for the rater to write his comments in a statement of 100-300 words on the performance of each operator.

Operator Evaluation Form. It is recommended that the rater take each quality, one at a time, and judge the entire group he is rating on the basis of this one quality. The name of each operator should be written on individual pieces of paper. For example, in rating 20 people, he would have 20 sheets of paper, each with a single name. Then the rater would look at the quality (one of the 11) and carefully consider who is the best of this group and place his name on top. In like manner, the one who rates the lowest of this group on this particular quality would be put last. The rater would proceed in this manner until the entire group is arranged from best to the poorest. He may rearrange the order several times before he is satisfied. This is time consuming, but unless the rater takes care in this effort, the individual may not be judged fairly.

One thing to be on the look-out for is the so-called "halo effect." People with experience in this field find it difficult to rate a person in the correct place because of an outstanding characteristic the person being rated may have. The result is that the rater will give high standings on all qualities. In like manner, the situation can be reversed, if, in the rater's opinion, the man has an outstanding fault which tends to cause lower ratings on all qualities. Another obstacle to overcome in giving a fair rating is the rater's remembrance of one specific instance of trouble between himself and the operator. This is the type of situation a rater must leave behind and is to be distinguished from a recurring fault. A third obstacle the rater has to overcome is a particular characteristic he himself admires in a worker, since this will also prejudice his rating.

It should be pointed out that there is no spacing between each grade of a particular quality on the Operator Evaluation Form. After the names of the group have been arranged in order from the poorest to the best on one of the 11 qualities, Operator Evaluation Form is marked, using each operator's initials to identify his mark. For example, suppose five people are being rated, with the initials ISM, LRN, TES, RPB, and LEJ, on the qualities of operating technique, and, for simplicity of example, the first one (ISM) is best and the last one (LEJ) is poorest. The rater must choose where LEJ (the poorest) fits on the entire line of operating technique. He would put a mark with the initials either at the beginning of the grade line (slow, clumsy, or inept), or the middle, or the end of this grade line, or perhaps even at the beginning of the grade line (good technique), depending on where in his opinion the poorest man fits on <u>this specific quality only</u>. He should then decide where on the line the best (ISM) fits, place the mark with initials, and then arrange the remaining three where they fit between the two extremes. This system of arrangement of initials and marks should be followed for each of the 11 qualities.

Fig. 4-15 (Cont'd)

For further clarity, suppose 10 men are being rated. The rater should prepare 10 slips of paper, each with a name on it. These names should be arranged in the order of poorest to best for the first of the 11 qualities. After each satisfactory arrangement for one quality, the rater should transfer this information to the Operator Evaluation Form by employing a mark with the correct initials for each operator. This would result in 11 arrangements of the 10 men and the transfer of these 11 arrangements by initials to the Operator Evaluation Form.

Operator Progress Form. The final marking is to place on the Operator Progress Form (individual copy for each man) and not on the Operator Evaluation Form each man's initials under one of three headings: Has Improved, Has Gone Back, or Little or no Improvement. This is to be done for each man and for each quality since the last rating. This is also a sliding scale.

The rater obviously cannot fill in the Operator Progress Form unless he has previously rated the same group of men. This Operator Progress Form is provided in order for the rater to have more space for his markings.

Rater Comment Form. The rater is asked to comment on the performance of each operator in a statement of 100-300 words. The following should be included:

a. Good points of the operator as the rater sees them.
b. Main weakness or weaknesses of the operator.
c. Anything else that the rater thinks is pertiment; that is, anything else that might help in the personal development of the operator, or any statement that might increase the morale of the operator.

This Rater Comment Form normally will be shown to the operator at the same time that the Operator Evaluation Form, combined with the Operator Progress Form, is shown to him. For this reason, its language should be kind and sympathetic. To be completely fair and honest with the operator, however, the statement must reflect the whole truth.

Disposal of Forms

The Operator Evaluation Form and the Operator Progress Form are now delivered to the Section Chief, who has the following work done:

a. The marks (but not the initials) are transferred to a multilith mat of the Operator Evaluation Form.
b. The mat is reproduced, a copy being obtained for each man rated plus several extra copies.
c. Each operator's name is placed on a separate copy, and his ratings are identified by a red check. On the basis of the Operator Progress Form, the appropriate check is made under "Has Improved," "Has Gone Back," or "Little or No Improvement," on the Operator Evaluation Form.
d. On some occasions, it will be desirable to show an operator only his rating and not a comparison of his ratings with all other operators. In this case, a separate form showing only the one operator's rating will be prepared.

The Rater Comment Form in most cases will also be discussed with the operator at the same time.

Fig. 4-16

CHEMICAL TECHNOLOGY DIVISION

Pilot Plant Section

OPERATOR EVALUATION FORM

General Instructions: *Read* the separate instruction sheets before filling in this form. The exact position of each mark with initials on each specific grade is important. Rate the entire group on one quality before proceeding with the next quality. You are to use only one copy of this OPERATOR EVALUATION FORM for the entire group and an individual copy of the OPERATOR PROGRESS FORM for each person rated.

Consider the operator's work during the past______months and indicate whether he has gone back, remained stationary, or gone ahead in each of the qualities listed to the left. Do *NOT* fill these in on this sheet but on the OPERATOR PROGRESS FORM. *See instructions.*

Master or Individual Form ____________________

Rated For__________________ Date __________

					HAS GONE BACK	LITTLE OR NO CHANGE	HAS IMPROVED
1. **CURIOSITY** – Disposition to inquire about present and related jobs to increase job knowledge.	Shows essentially no curiosity.	Occasionally inquisitive.	Usually inquisitive.	Eager to investigate. Habitually inquisitive.			
2. **INDUSTRY AND INITIATIVE** – Does employee apply attention, energy, enthusiasm, and persistence to his work. Does he need constant prodding, or does he have a drive to determine what should be done and then start and follow it through to completion.	Lazy, needs much prodding.	Rather indifferent, needs occasional prodding.	Does ordinary assignments of own accord and fairly well.	Does far more than is expected. Sets and completes additional tasks.			
3. **JUDGMENT** – Ability to size up a situation and pick the right course. Is his judgment dependable even under stress? Is he hasty, erratic, biased, swayed by his feelings?	Notably lacking in judgment.	Acts normally in ordinary circumstances, but may be hasty in emergencies.	Habitually shows good judgment.	Shows unusually sound judgment under all circumstances.			
4. **ALERTNESS** – Ability to pick up variations and details of operation.	Unable to go beyond routine.	Seldom notices variations or details of operation.	Often aware of details beyond routine operations.	Able to keep all phases of operation in mind. Very little escapes his attention. Very sharp.			
5. **QUALITY OF WORK** – The degree to which statements, calculations, data, recordings, and equipment operation are free from error.	Slipshod and careless. Constant checking required.	Sometimes requires observation and prodding to do job properly. Frequent checking required.	Usually accurate and dependable. Very little checking required.	Exceptionally free from error.			
6. **ABILITY TO LEARN** – The speed in learning new methods and learning to operate new equipment and the speed of becoming oriented when faced by new situations on unfamiliar problems.	Easily baffled or confused. Very slow to adapt to new conditions.	Moderate ability.	Quick.	Exceptionally fast in learning to operate new equipment, and in grasping new ideas, methods, situations.			
7. **COOPERATION** – Consider his ability in acting jointly with associates and superiors for the benefit of the group.	Cooperates grudgingly. Frequently causes friction.	Gives limited cooperation. Sometimes troublesome to supervisors and operators.	Usually cooperates willingly. Works well with others.	Cooperates cheerfully and consistently and inspires cooperation.			
8. **OPERATING TECHNIQUE**	Slow, clumsy, or inept.	Fair technique, somewhat lacking.	Good technique.	Very fast and adept.			
9. **COMPREHENSION OF OPERATING TECHNIQUE**	Unable to understand or work with equipment.	Fair understanding.	Good understanding.	Very good at analyzing, comprehending, and working with mechanical and chemical engineering equipment.			
10. **ACCEPTANCE OF CONSTRUCTIVE CRITICISM**	Surly, resents criticism.	Accepts criticism; makes limited effort to improve.	Accepts criticism readily and tries to improve.	Shows genuine interest; seeks criticism, and makes strong effort to profit from it.			
11. **RELIABILITY** – Consider the reliability of the employee in the discharge of every duty. Does he carry his full share of responsibility?	Indifferent, does as little as he can, needs constant watching, often fails to deliver.	Sometimes unreliable. Avoids responsibility. Satisfied to "get by."	Very dependable. Seldom disappoints.	Exceptionally dependable. Consistently constructive force in his group.			

Fig. 4-17

OPERATOR ____________________

CHEMICAL TECHNOLOGY DIVISION

Pilot Plant Section

OPERATOR PROGRESS FORM

QUALITY	HAS GONE BACK	LITTLE OR NO IMPROVEMENT	HAS IMPROVED
Curiosity	________	________	________
Industry and Initiative	________	________	________
Judgment	________	________	________
Alertness	________	________	________
Quality of Work	________	________	________
Ability to Learn	________	________	________
Cooperation	________	________	________
Operating Technique	________	________	________
Comprehension of Operating Technique	________	________	________
Acceptance of Constructive Criticism	________	________	________
Reliability	________	________	________

RATER ____________________

DATE ____________________

Fig. 4-18

CHEMICAL TECHNOLOGY DIVISION

Pilot Plant Section

RATER COMMENT FORM

NAME ______________________ DATE ______________ RATED BY ______________

Please comment on the performance of each operator in a statement of 100-300 words. PLEASE read the separate instruction sheet before completing this form.

4.10.2 Training a Data Analyst

Training a data analyst may require 12 to 18 months and may be conveniently divided into four steps. The first step is an indoctrination period lasting about a month. Following this, the analyst should be given limited assignments lasting from three to six months, depending upon the problem and the individual. After the data analyst demonstrates that he can handle limited assignments, he should be assigned one phase of the process, being completely responsible for everything done in the process that relates to this phase. Finally, the data analyst should prepare himself to organize and administer a data group. This preparation may require six months to one year of experience. The amount of time that a data analyst spends on each step will depend to some extent on the individual and to a somewhat greater extent on his technical background.

In the orientation step, the analyst should become familiar with the process background. The objectives, as well as the scope and limitations of the process, should be thoroughly understood by the analyst. This can best be obtained by reading reports that were issued during laboratory development of the process. Also helpful will be conferences with members of the organization who are familiar with the process. The analyst should study process and equipment flowsheets, and should become familiar with the assembled plant. Soon after becoming a member of a data group, the data analyst should become familiar with the type of data that is required to control and evaluate the process being considered. At the same time, the value and validity of each type of data will become familiar to him. The orientation period also includes a study of the method of keeping up-to-date records of data, such as production, losses, decontamination factors, source and fissionable materials inventories, etc.

The second step of training, that of limited assignments, should consist of a period in which the analyst is responsible for assembling, tabulating, and organizing data, and, with the help of an experienced person, evaluating the data.

The third phase in the training of an analyst, that of assuming responsibility for one phase of a process, should be divided into two periods: first, the analyst assembles, organizes, and evaluates data, and second, writes sections of the report pertaining to these data.

The fourth step, that of responsibility for the organization and administration of a data group, may be divided into four parts. First, the analyst should learn to organize records by establishing simple standard accounting procedures. The process should be broken down into logical steps, and the individual steps divided into groups of operations that involve sections of the plant. The data analyst should be aware of the necessity for keeping account of every quantity of material entering the plant, which must be accounted for at each step in process. He should design simple and straightforward reporting forms which will enable the tabulators to keep adequate records. Second, he should learn to organize personnel assigned to a data group. He should assign specific responsibilities to individuals in the group according to the talents and backgrounds of individuals in the group. He should strive to broaden the knowledge of the group by a continuing training program and allowing the individual to exchange responsibilities, so that when a personnel loss or turnover occurs the group will continue to function adequately. Third, the data analyst should learn to organize, write, and publish run summaries and all other types of reports issued by a data section. Fourth, he should learn to establish sampling requirements for a program and to maintain close liaison with the analytical laboratory and other groups.

4.10.3 Evaluation of Technical Personnel

The Chief of the Pilot Plant Section had for some time counseled junior technical personnel, helping them to develop their full potential as an engineer. As the location of pilot plants operated by the Section spread out to several buildings, it became increasingly more difficult to counsel the junior technical personnel based on actual job performance. To assist the Section Chief, a Technical Personnel Evaluation Form was constructed. This form (Fig. 4-19, 20) provides a means for problem leaders to transmit to the Section Chief their evaluations of the technical people under their supervision.

It should be emphasized that this evaluation form is not used for merit rating; it is used solely by the Section Chief for private discussion with the individual evaluated. The completed evaluation form is confidential to the Section Chief, the evaluator, and the person evaluated.

Fig. 4–19

Instructions for Completing Technical Personnel Evaluation Form

INTRODUCTION

You are being requested to evaluate technical personnel with whom you have been closely associated for some time. It cannot be overemphasized that your evaluation should be written only after very careful consideration of the individual and comparison of the individual to others with about the same training and experience. Obviously, your comments are expected to reflect your professional integrity, stature, and judgment.

There are three main parts to this evaluation form. Part A, Specific Evaluations, consists of thirteen factors that relate to the engineer's traits and promotion potential. Each factor is defined in four degrees, and should you place a mark in one of the two starred (*) columns, you are requested to justify your evaluation in the space immediately following Part A.

Part B, Job Performance, consists of ten pilot plant jobs and five degrees of performance. Normally, the engineer can be rated in one of the ten jobs; however, if this is not possible, a space is provided for rating the individual under "special assignment."

Part C, Over-All Comparison, provides an opportunity to compare this engineer to others that you know with about the same background and experience. Also, you are to write in each of the five spaces provided the number of engineers that you have designated in each category.

Following Parts B and C, you are to write the outstanding characteristics and any weaknesses that the engineer has that seriously affect his job performance.

Finally, sign your name to the form, date it, and state the period in which your evaluation is based.

Use one form for each engineer that you are rating.

Part A

In Part A, Specific Evaluations, you are to indicate by a mark (√) the exact position on the scale at which you feel the engineer has exhibited each of thirteen traits or characteristics. Use the entire length of the scale, ignoring the vertical lines.

It is best to rate all engineers on a single characteristic, in this case beginning with "Knowledge of Field," before going to the second characteristic. Classify the engineers that you are rating into as many groups as necessary so that each group represents about the same training and background. Then sort each group, beginning with whom in your opinion exhibits the highest degree of attainment, the next highest, and so on until the lowest. You should now have a comparison of each person being rated relative to the whole group that you are rating. After you have done this, carefully consider each man's position on the scale, and on each individual form, place a mark on the scale representing that position.

Continue in this manner until you have completed Part A.

Should you rate any person at the top or bottom parts of the scale, as indicated by starred (*) columns, you are to write specifically what factors were considered to justify your evaluation. Space for your writing has been provided at the bottom of Part A.

Part B

In Part B, you are to evaluate each engineer on job performance in possibly one or more usual pilot plant jobs. Ten jobs are listed with five degrees of performance. As in Part A, the entire scale is to be used; the vertical lines are to be ignored. If one of the ten titles does not describe the job, use the title "Special Assignment" and describe the assignment in the space provided immediately following the scales.

If you have not observed the engineer in the jobs described, place a check mark in the column titled "Not Observed."

Fig. 4-19 (contd.)

Part C

Part C provides a scale for designating how you compare the engineer with other engineers you know having about the same training and experience. Mark on line (a) your evaluation in the exact position that represents your evaluation.

On line (b) write in the number of engineers that you have designated in each category of line (a). For example, if you are evaluating 10 engineers, you may have evaluated one as being "one of the few highly outstanding engineers I know," and thus, you would write the numeral 1 under the column with the quoted title. The other 9 engineers would be distributed under the remaining four categories. The sum of the numbers on line (b) should equal the number of persons you are evaluating.

Immediately following Part C, you are to write your appraisal of any outstanding characteristics and any weaknesses which seriously affect the job performance by the engineer. Your comments should be concise and concrete and should cite specific examples to bear out your appraisal.

Signing the Evaluation Form

Each form should be dated and signed. Also, you are requested to fill in the time period, month and year beginning and month and year ending, on which your evaluation is based.

After completing the forms, you should return them to the Section Chief.

Fig. 4-20

X-755

CHEMICAL TECHNOLOGY DIVISION
PILOT PLANT SECTION
TECHNICAL PERSONNEL EVALUATION FORM
FIELD: CHEMICAL ENGINEER IN PILOT PLANT DEVELOPMENT

Person Rated____________________

General Instructions: Read the separate instruction sheets before filling in this form. The exact position of each mark placed on this form is important. You are to rate only one individual on this form.

A. SPECIFIC EVALUATION:	*			*
1. Knowledge of Field	Knowledge of field is inadequate.	General and specific grasp of field is average or below. Knowledge not always adequate.	Knowledge of field is above average and completely adequate.	Has exceptional knowledge of field, both comprehensive and specific.
2. Management Effectiveness	Is needlessly wasteful of men, money, and materials.	Utilizes men, money, and materials in a barely satisfactory manner.	Conserves men, money, and materials effectively by implementing and maintaining routine management procedures.	Is most effective in utilization of men, money, and materials.
3. Cooperation	Cooperates grudgingly. Frequently causes friction.	Gives limited cooperation. Sometimes troublesome to supervision.	Usually cooperates willingly. Works well with others.	Cooperates cheerfully and consistently. Inspires cooperation.
4. Acceptance of Constructive Criticism	Resents criticism.	Accepts criticism. Makes only limited effort to improve.	Accepts criticism readily and tries to improve.	Shows genuine interest. Seeks criticism and makes strong effort to profit from it.
5. Ingenuity – Originality	Seriously lacking in capacity for original research. No ingenuity; hence, cannot cope with any unusual problems.	Shows average or less ability to think creatively or to make original contributions. Routine rather than ingenious.	Very good in devising and executing original research. Above average in developing new techniques and coping with new problems.	Unusual degree of creative and problem-solving ability. Outstanding research man in originality and ingenuity.
6. Scientific Judgment	Far below acceptable standards with regard to scientific judgment. Requires excessive supervision and direction.	Average or below in ability to plan and carry out significant research. May fail to show discriminating judgment. Needs close supervision.	Shows very satisfactory judgment in research, reflected in intelligent planning, execution, and evaluation. Needs only general direction.	Has exceptional ability to select, plan, and carry out significant research projects and to properly evaluate results. Needs minimum supervision.
7. Leadership	No leadership ability.	Leadership ability not very effective. Tends to lose control of his subordinates. More of a follower than a leader.	A consistently good leader. Gets respect from his subordinates. Is effective under difficult circumstances.	Outstanding skill in directing others results in a very effective group. Inspires confidence even under very difficult circumstances.
8. Promotion Potential	Definitely limited. Is at about his maximum capacity.	At present time is not promotional material. Should receive further training and future consideration.	Very promising promotional material.	Capable of increased responsibility and rapid advancement.
9. Teaching Ability	Seriously lacking in ability. Even with further help he probably would not improve.	Average or below in ability to convey his knowledge to subordinates. Needs training in methods to improve his ability.	Ability to teach and train is above average. His subordinates show good knowledge of job and are well trained.	Has exceptional ability to teach and train subordinates, resulting in a well trained group that thoroughly understands their job.
10. Productivity	Unsatisfactory amount of completed work. Fails to utilize time or facilities to best advantage.	Average or below in completing projects in relation to time expended. May not put time or facilities to best use.	Above average in turning out results. Uses time and facilities to good advantage.	Unusually productive. Maximum utilization of time and facilities. Excellent application to project at hand.
11. Versatility – Adaptability	No versatility. Unwilling or unable to adjust to new demands.	Average or below. May show resistance to change. Tends to be stereotyped.	Above average in adapting self to new methods, assignments, and variety of problems.	Extremely versatile. Can handle wide variety of problems.
12. Quality of Work	Quality is below acceptable standards. Results frequently are poor in thoroughness and accuracy.	Sometimes lacks accuracy or thoroughness. Average or below in quality.	Quality is very satisfactory. Above average in all aspects relating to quality.	Extremely thorough, accurate, and painstaking. Work is of high quality in approach and execution, content and form.
13. Reporting Ability: Verbal and Written	Reports are unsatisfactory. Usually lacking in clarity, organization, and content.	Reports may be lacking in content or form. No more than average	Very satisfactory in recognizing and reporting significant data.	Excellent in reporting. Clear, concise, and logical.

Fig. 4-20 (con't)

X-755A

Referring to Part A: Marks under the starred (*) columns must be justified in this section with a brief description of the factors which were considered in evaluating the engineer. The justification should be in concrete and specific terms.

B. JOB PERFORMANCE: Carefully place a mark on the following scales that represents your over-all evaluation of how the person did his job.

Duty	Not Observed	Inadequate performance in many of his duties. Needs close supervision. He is not qualified.	Satisfactory performance in most aspects of his duties. Needs some supervision. Basically qualified.	Competent and efficient performance in most aspects of his duties. Frequently demonstrates excellent performance.	Excellent performance in most aspects of his duties. Efficient or competent in most of the remaining aspects. Frequently demonstrates outstanding performance.	Outstanding performance in most aspects of his duties. Highly qualified.
Problem Leader						
Process Chemist						
Engineering Group Supervisor						
Construction and Maintenance						
Operations Group Supervisor						
Data Group Supervisor						
Shift Supervisor						
Assistant Shift Supervisor						
Process Engineering						
Data Analyst						
*Special Assignment						

*Describe special assignment observed.

C. 1. In comparison with other engineers of his pilot plant job title and approximate length of service, how would you designate this engineer in line (a) below.

2. For this rating period indicate in (b) how many engineers you have designated in each category of (a).

	One of the few highly outstanding engineers I know.	A very fine engineer of great value to the section.	A dependable and typically effective engineer.	An acceptable engineer.	Unsatisfactory.
(a)					
(b)					

Referring to parts B and C: Report the outstanding characteristics and any weaknesses of the engineer which seriously affect his job performance. The appraisal should be concise and concrete in terms of specific examples.

Date__________ Rater's Name__________ Period Rated: Beginning__________ Ending__________

4.11 Waste Storage and Disposal Services

As long as waste is in a pilot plant, it is the responsibility of the Pilot Plant Section to handle it properly and to make certain that it is delivered to the proper drain. After waste leaves the pilot plant, it is the responsibility of the Operations Division to make certain that it reaches the proper destination. To clarify the details of these responsibilities, they are listed as follows:

4.11.1 Pilot Plant Section Responsibilities

1. To notify the Operations Division when waste of a certain type and quantity is ready to be sent from the plant. The pilot plant should recommend place of storage or disposal, giving full details of composition and activity level and any unusual conditions concerning it.
2. To deliver the waste to the proper drain in the building after the Operations Division has notified the pilot plant that the tank farm valves are set to the proper destination.
3. To notify the Operations Division when all the waste has been delivered to the pilot plant drain.

4.11.2 Operations Division Responsibilities

1. To set the tank farm valves to deliver the waste to the destination recommended by the pilot plant, unless this choice of destination conflicts with Laboratory waste disposal policy.
2. To close all valves after each waste transfer is complete.
3. To monitor waste by keeping a record of its volume and of radioactivity discharged to White Oak Creek.

5.0 REFERENCES

1. H. K. Jackson, "Information Required for a Pilot Plant Program," ORNL CF-52-6-95 (July 17, 1952).

2. H. K. Jackson, "A Few Miscellaneous Notes on the Responsibilities of Problem Leaders in the Pilot Plant," memo to Pilot Plant Problem Leaders dated January 13, 1953.

3. F. L. Culler, "Notes on the Committee System," ORNL CF-53-9-47 (Sept. 9, 1953).

4. F. L. Culler, memo to all Chemical Technology Division personnel, dated Sept. 22, 1955.

5. W. E. Unger, letter to F. L. Culler, dated Jan. 8, 1954.

6. J. P. Jarvis, "The Organization of a Construction Program," ORNL CF-55-3-207 (Mar. 23, 1955).

7. G. W. T. Kearsley and H. H. Messenheimer, "General Outline, Pre-Hot Run Manual," ORNL CF-54-8-77 (Aug. 5, 1954).

8. H. H. Messenheimer, "Evaluation of the Thorex Pilot Plant Pre-Operational Program," ORNL CF-55-8-113 (Aug. 17, 1955).

9. R. B. Lindauer, ORNL CF-53-5-152 (May 18, 1952).

10. G. S. Sadowski, "Test Facility Analytical Services Procedures," ORNL CF-53-9-73 (Sept. 14, 1953).

11. H. K. Jackson and G. S. Sadowski, ORNL CF-53-11-201 (Nov. 24, 1953).

12. G. S. Sadowski, ORNL CF-53-1-325 (Jan. 16, 1953).

13. G. S. Sadowski, "An Analysis of Chemical Technology Division Analytical Costs for June 1954," ORNL CF-54-7-185 (July 27, 1954).

14. G. S. Sadowski, "Analytical Costs: Chemical Technology Division Analytical Cost Data for the Period of February 1954 through April 1955," ORNL CF-55-6-171 (June 22, 1955).

15. G. S. Sadowski, "Analytical Costs: General Conclusions and Recommendations on Chemical Technology Division Analytical Costs," memo to F. L. Culler dated June 6, 1955.

16. W. K. Eister and M. W. Gerrard, "Preparation of Topical Reports," ORNL CF-52-4-95, Revised (July 21, 1952).

17. P. M. Reyling, "Preparation of Reports," ORNL-1454 (Mar. 4, 1953).

18. R. E. Brooksbank, J. L. Matherne, and W. R. Whitson, ORNL-1850 (Feb. 16, 1955).

19. J. M. Chandler and D. O. Darby, ORNL-1519 (Feb. 8, 1954).

20. J. L. Matherne, ORNL-1941 (Aug. 23, 1955).

21. J. L. Matherne, ORNL CF-55-6-185 (June 27, 1955).

22. W. D. Burch, ORNL CF-54-9-154 (Sept. 22, 1952).

23. R. B. Lindauer, W. D. Burch, and B. H. Morrison, ORNL CF-54-11-124 (Dec. 1, 1954).

24. J. M. Chandler and K. H. McCorkle, ORNL CF-53-5-44 (May 7, 1953).

25. W. T. McDuffee and C. V. Ellison, ORNL CF-55-10-107 (Oct. 18, 1955).

26. G. S. Sadowski, ORNL CF-55-6-81 (June 16, 1955).

27. W. H. Lewis, ORNL CF-54-8-80 (Aug. 13, 1954).

28. G. S. Sadowski, ORNL CF-53-3-181 (Mar. 12, 1953).

29. G. S. Sadowski, ORNL CF-52-8-211 (Aug. 25, 1952).

30. G. S. Sadowski, "Pilot Plant Section Budget Status January 1955," ORNL CF-55-3-180 (Mar. 18, 1955).

31. R. H. Winget, "Thorex: Thorex Money Status and Construction Status as of October 1, 1954," ORNL CF-54-10-143 (Oct. 26, 1954).

32. R. B. Lindauer, "Preliminary Outline of Test Facility Operating Manual," ORNL CF-53-2-124 (Feb. 12, 1953).

33. R. B. Lindauer, ORNL CF-53-10-177 (Oct. 27, 1953).

34. G. S. Sadowski, ORNL CF-53-3-47 (Mar. 9, 1953).

35. G. S. Sadowski, ORNL CF-52-8-55 (Aug. 11, 1952).

36. G. S. Sadowski, ORNL CF-52-10-127 (Oct. 14, 1952).

37. H. H. Messenheimer, ORNL CF-55-6-162 (June 3, 1955).

38. H. K. Jackson, "Synthetic Protective Clothing Worn in the Test Facility," ORNL CF-54-9-90 (Sept. 13, 1954).

39. E. J. Witkowski and P. B. Orr, "Protective Clothing Tests," ORNL CF-55-9-124.